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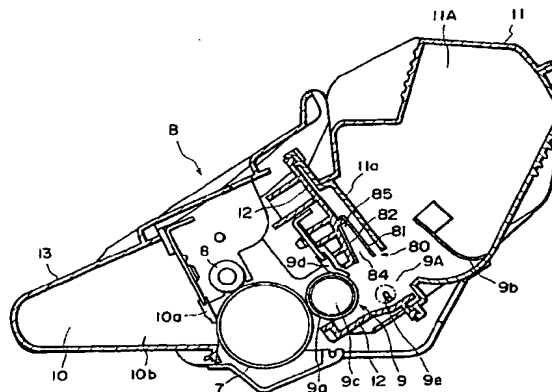
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(54) **Image developing apparatus, process cartridge, electrophotographic image forming apparatus, and development unit frame**

(57) A developing device for developing an electrostatic latent image formed on an electrophotographic photosensitive member, said developing device being mountable to a main assembly of an electrophotographic image forming apparatus, said developing device includes a developer carrying member for feeding a developer to said electrophotographic photosensitive member to develop the electrostatic latent image formed on the electrophotographic photosensitive member; a first electroconductive portion; a second electroconductive portion for cooperating with said first electroconductive portion to provide an electrostatic ca-

capacity; a first electrical contact for receiving a voltage to be applied to said first electroconductive portion from the main assembly of the electrophotographic image forming apparatus; a second electrical contact for transmitting, to the main assembly of the electrophotographic image forming apparatus, an electric signal corresponding to an electrostatic capacity between said first electroconductive portion and said second electroconductive portion when a voltage is applied to said first electroconductive portion to detect a remaining amount of the developer by the main assembly of the electrophotographic image forming apparatus.



**FIG. 3**

## Description

### FIELD OF THE INVENTION AND RELATED ART

**[0001]** The present invention relates to an image developing apparatus, a process cartridge, an electrophotographic image forming apparatus, and a development unit frame.

**[0002]** An electrophotographic image forming apparatus includes an electrophotographic copying machine, an electrophotographic printer (for example, LED printer, laser beam printer, and the like), an electrophotographic facsimile apparatus, an electrophotographic word processor, and the like.

**[0003]** A process cartridge is a cartridge which integrally comprises a charging means, a developing means or a cleaning means, and an electrophotographic photosensitive member, and is removably installable in the main assembly of an electrophotographic image forming apparatus; or a cartridge which integrally comprises at least a developing means, and an electrophotographic photosensitive member, and is removably installable in the main assembly of an image forming apparatus.

**[0004]** In the past, an image forming apparatus which employed an electrophotographic image formation process employed a process cartridge system, according to which an electrophotographic photosensitive member, and one or a plurality of processing means which works on the electrophotographic photosensitive member, are integrally assembled in the form of a cartridge removably installable in the main assembly of an image forming apparatus. Also according to this process cartridge system, the maintenance for an image forming apparatus can be performed by a user him/her self; the user does not need to rely on a service person for the maintenance. Therefore, the employment of a process cartridge system drastically improved the operational efficiency of an image forming apparatus. As a result, a process cartridge system has been widely used in the field of the image forming apparatus.

**[0005]** In the case of an image forming apparatus such as the above described electrophotographic image forming apparatus which employs a process cartridge system, a user him/herself must exchange a cartridge. Therefore, the image forming apparatus is provided with a means for informing the user of developer depletion, for example, an developer amount detecting apparatus.

**[0006]** In the past, in order to detect the amount of developer remainder, a pair of electrodes in the form of a rod are placed in the developer container of a developing means, and the amount of the developer in the developer container was determined by detecting the changes which occurred to the electrostatic capacity between the two electrodes.

**[0007]** Japanese Laid-Open Patent Application No. 100571/1993 discloses a developer amount detecting apparatus, which employs a developer amount detect-

ing member comprising two electrodes placed in the same plane in parallel to each other, one being in the shape of a "U", and the other being in the shape of a "I" so that they can be coupled on the same plane. This developer amount detecting member is located at the bottom portion of the developer container. This development amount detecting apparatus detects the amount of remaining developer by detecting the fluctuation in the electrostatic capacity between the parallel electrodes placed in the same plane.

**[0008]** However, the above described developer amount detecting apparatus is of a type which detects the presence (absence) of the developer within the developer container. More specifically, it is of a type that detects the developer shortage only immediately before the depletion of the developer within the developer container. In other words, it is not enabled to continuously detect how much developer remained in the developer container.

**[0009]** Thus, if it is possible to continuously detect the amount of the developer remaining in the developer container, a user can know the state of developer usage in the developer container, which makes it possible for the user to prepare a new process cartridge for exchange. This is very convenient for the user.

### SUMMARY OF THE INVENTION

**[0010]** The primary object of the present invention is to provide an image developing apparatus, a process cartridge, and an electrophotographic image forming apparatus, which are capable of continuously detecting the amount of the developer remainder, and a developing apparatus usable for a process cartridge and an electrophotographic image forming apparatus.

**[0011]** Another object of the present invention is to provide an electrophotographic image forming apparatus, which comprises a developer amount detecting means capable of continuously detecting the amount of the developer remainder in accordance with the consumption of the developer within the developer container, to offer more convenience to a user in terms of usage, as well as a process cartridge, a developing apparatus, and a development unit frame, which are compatible with the above electrophotographic image forming apparatus.

**[0012]** Another object of the present invention is to provide a development unit frame better designed for improving the aforementioned process cartridge and developing apparatus in terms of quality and assembly efficiency, and also, installing the developer amount detecting means, or the like, capable of continuously detecting the amount of the developer in the development chamber in accordance with the developer consumption, into the aforementioned process cartridge or developing apparatus.

**[0013]** According to an aspect of the present invention, a developing apparatus, a process cartridge, or an

electrophotographic image forming apparatus which employs a developing apparatus and a process cartridge, comprises: a first electrically conductive portion; a second electrically conductive portion opposing the first electrically conductive portion to provide electrostatic capacity between the first and second electrically conductive portions; a first electrical contact for receiving the voltage to be applied to the first electrically conductive portion, from the electrophotographic image forming apparatus main assembly; and a second electrical contact for transmitting to the electrophotographic image forming apparatus main assembly, electrical signals generated in accordance with the electrostatic capacity provided between the first and second electrically conductive portions, as voltage is applied to the first electrically conductive portion, in order to enable the electrophotographic image forming apparatus main assembly to detect the amount of the remaining developer.

[0014] These and other objects, features and advantages of the present invention will become more apparent upon a consideration of the following description of the preferred embodiments of the present invention taken in conjunction with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Figure 1 is a schematic vertical sectional view of an example of an electrophotographic image forming apparatus in accordance with the present invention, and depicts the general structure thereof.

[0016] Figure 2 is an external perspective view of the electrophotographic image forming apparatus in accordance with the present invention.

[0017] Figure 3 is a vertical cross sectional view of a process cartridge in accordance with the present invention.

[0018] Figure 4 is an external perspective view of the process cartridge in accordance with the present invention as seen from the bottom side.

[0019] Figure 5 is an external perspective view of the cartridge installation chamber in the main assembly of the process cartridge in accordance with the present invention.

[0020] Figure 6 is a perspective view of the partially disassembled development unit frame, and depicts an example of the structural configuration for connecting electrodes of the developer amount detecting apparatus in accordance with the present invention.

[0021] Figure 7 is a graph which shows the relationship between the toner amount and electrostatic capacity in the developer amount detecting apparatus in accordance with the present invention.

[0022] Figure 8 is a perspective view of the first and second electrodes in the developer amount detecting apparatus in accordance with the present invention.

[0023] Figure 9 is a vertical cross-sectional view of another example of the process cartridge in accordance with the present invention.

[0024] Figure 10 is a vertical cross-sectional view of another example of the process cartridge in accordance with the present invention.

[0025] Figure 11 is a perspective view of the development unit frame, and depicts how the first and second electrodes are attached to the development unit frame.

[0026] Figure 12 is a perspective view of the development unit frame, and depicts another way the first and second electrodes are attached to the development unit frame.

[0027] Figure 13 is a vertical cross-sectional view of the process cartridge in accordance with the present invention, and depicts how the developer is circulated in the development chamber.

[0028] Figure 14 is a vertical cross-sectional view of the process cartridge in accordance with the present invention, and depicts how the developer is circulated in the development chamber.

[0029] Figure 15 is a vertical cross-sectional view of the process cartridge in accordance with the present invention, and depicts how the developer is circulated in the development chamber.

[0030] Figure 16 is a vertical cross-sectional view of the process cartridge in accordance with the present invention, and depicts how the developer is circulated in the development chamber.

[0031] Figure 17 is a vertical sectional view of the process cartridge in another embodiment of the present invention.

[0032] Figure 18 is a perspective view of the development unit frame in the first embodiment of the present invention, and depicts how the first and second electrodes are attached to the development unit frame.

[0033] Figure 19 is a vertical sectional view of the process cartridge in another embodiment of the present invention.

[0034] Figure 20 is a vertical sectional view of the process cartridge in another embodiment of the present invention.

[0035] Figure 21 is a vertical sectional view of the process cartridge in another embodiment of the present invention.

[0036] Figure 22 is the diagram of the developer amount detection circuit for the developer amount detecting apparatus in the first embodiment of the present invention.

[0037] Figure 23 is a schematic drawing of an example of a developer amount gauge.

[0038] Figure 24 is a schematic drawing of another example of a developer amount gauge.

[0039] Figure 25 is a vertical sectional view of the process cartridge in another embodiment of the present invention.

[0040] Figure 26 is a longitudinal sectional view of a process cartridge according to an embodiment of the present invention.

[0041] Figure 27 is the diagram of the developer amount detection circuit for the developer amount de-

tecting apparatus in the another embodiment of the present invention.

**[0042]** Figure 28 is a graph which depicts the developer amount detection principle in accordance with the present invention.

**[0043]** Figure 29 is a vertical cross-sectional view of the process cartridge in another embodiment of the present invention.

**[0044]** Figure 30 is a vertical sectional view of an example of a developing apparatus equipped with the developer amount detecting apparatus in accordance with the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

**[0045]** Hereinafter, an image developing apparatus, a process cartridge, an electrophotographic image forming apparatus, and a development unit frame, which are in accordance with the present invention will be described in more detail with reference to the appended drawings.

#### Embodiment 1

**[0046]** First, referring to Figure 1, an example of an electrophotographic image forming apparatus in which a process cartridge configured in accordance with the present invention is installable will be described. The electrophotographic image forming apparatus in this embodiment is an electrophotographic laser beam printer, which forms images on various recording media, for example, recording paper, OHP sheet, fabric, and the like, with the use of an electrophotographic image formation process.

**[0047]** A laser beam printer A is provided with an electrophotographic photosensitive member in the form of a drum, that is, a photosensitive drum 7. The photosensitive drum 7 is charged by a charge roller 8, i.e., a charging means. Then, a laser beam modulated with image data is projected onto the photosensitive drum 7, from an optical means 1 comprising a laser diode 1a, a polygon mirror 1b, a lens 1c, and a deflection mirror 1d. As a result, a latent image is formed on the photosensitive drum 7 in correspondence to the image data. This latent image is developed into a toner image, i.e., a visible image, by a developing means 9.

**[0048]** Referring to Figure 3, which makes it easier to understand the following description, the developing means 9 is provided with a development chamber 9A in which a development roller 9a as a developer bearing member is disposed. The developer in a developer container 11A, as a developer storage portion, located next to the development chamber 9A is sent to the development roller 9a by the rotation of a developer sending member 9b. In the development chamber 9A, a developer stirring member 9e is disposed adjacent to the development roller 9a, to circulate the developer in the de-

velopment chamber 9A. The development roller 9a contains a stationary magnet 9c. As the development roller 9a is rotated, the developer is borne and carried by the peripheral surface of the development roller 9a. Then, as the development roller 9a is rotated further, the developer on the development roller 9a is regulated by a development blade 9d into a developer layer with a predetermined thickness, while being triboelectrically charged, and is delivered to the image developing area. In this image developing area, the developer is transferred from the development roller 9a onto the latent image on the photosensitive drum 7. As a result, a toner image is formed on the photosensitive drum 7. The development roller 9a is connected to a development bias circuit so that development bias is applied to the development roller 9a. Normally, the development bias is compound bias comprising AC voltage and DC voltage.

**[0049]** Meanwhile, a piece of recording medium 2 is conveyed from a sheet feeder cassette 3a, which stores plural sheets of recording medium 2, to an image transfer area by a combination of a pickup roller 3b, conveyer roller pairs 3c and 3d, and a registration roller pair 3e, in synchronism with the progress of the toner image formation. In the transfer area, a transfer roller 4 as an image transferring means is disposed, and as voltage is applied to the transfer roller 4, the toner image on the photosensitive drum 7 is transferred onto the recording medium 2.

**[0050]** After the transfer, the recording medium 2 is conveyed to a fixing means 5 along a conveyer guide 3f, and passed through the fixing means 5, which comprises a driving roller 5c, and a fixing roller 5b containing a heater 5a. As the recording medium 2 is passed through the fixing means 5, the toner image having been transferred onto the recording medium 2 is fixed to the recording medium 2 with the application of heat and pressure from the fixing means 5.

**[0051]** Thereafter, the recording medium 2 is advanced further, is passed through a reversal path 3j, and then, is discharged into a delivery tray 6, by discharge roller pairs 3g, 3h and 3i. The delivery tray 6 is located at the top of the main assembly 14 of the laser beam printer A, i.e., an electrophotographic image forming apparatus. It should be noted here that the recording medium 2 can be discharged from the apparatus main assembly 14, without going through the reversing path 3j, by activating a flapper 3k. In such a case, the recording medium 2 is discharged by a discharge roller pair 3m. In this embodiment, the aforementioned pickup roller 3b, conveyer roller pairs 3b, 3c and 3d, and registration roller pair 3e, conveyance guide 3f, discharge roller pairs 3g, 3h and 3i, and discharger roller pair 3m, make up the conveying means.

**[0052]** After the toner image transfer onto the recording medium 2 by the transfer roller 4, the photosensitive drum 7 is cleaned by a cleaning means 10; the developer remaining on the photosensitive drum 7 is removed by the cleaning means 10. Then, the photosensitive

drum 7 is reused for the following cycle of image formation process. The cleaning means 10 comprises an elastic cleaning blade 10a placed in contact with the photosensitive drum 7. It scrapes away the toner remaining on the photosensitive drum 7 from the photosensitive drum 7, and collects it into a waste toner bin 10b.

**[0053]** Referring to Figure 3, the process cartridge B in this embodiment is an integral assembly of various frames and components therein. In production, a development unit (which makes up the developing apparatus portion) is formed by a welding a developer storage frame 11 comprising a developer container (developer storage portion) for storing the developer, and a developer conveying member 9b, to a development unit frame 12 which holds the developing means 9 made up of the development roller 9a, development blade 9d, and the like. Then, the process cartridge B is completed by integrally uniting this development unit with a cleaning unit frame 13 in which the photosensitive drum 7, the cleaning means 10 made up of the cleaning blade 10a and the like, and the charger roller 8, are disposed.

**[0054]** The process cartridge B is rendered removably installable in the cartridge installing means with which the main assembly 14 of an electrophotographic image forming apparatus is provided. The cartridge installing means in this embodiment is made up of a guiding means 13R (13L) formed as a part of the external right (left) wall of the process cartridge B (Figure 4), and guide portions 16R (16L) (Figure 5) formed as a part of the apparatus main assembly 14, in which the guiding means 13R (13L) is insertable.

**[0055]** Further, the process cartridge B in this embodiment is provided with a developer amount detecting apparatus as a means capable of continuously detecting the amount of the developer remainder in the development chamber 9A as the developer in the development chamber 9A is consumed.

**[0056]** Referring to Figure 3, the developer amount detecting apparatus in this embodiment comprises first and second electrically conductive portions (electrodes) 81 and 82, which are measurement electrodes, and are parts of developer detecting portion 80. The electrodes 81 and 82 are disposed along the development roller 9a. In order to detect the amount of the developer, voltage is applied to the first electrode 81 or the second electrode 82 to induce static electricity between the electrodes 81 and 82, so that the amount of the developer is calculated from the measurement of the amount of the electrostatic capacity between the two electrodes 81 and 82. In this embodiment, voltage is applied to the first electrode 81. This process will be described later in detail.

**[0057]** The magnetic developer is attracted to the peripheral surface of the development roller 9a by the magnetic roller 9c contained in the developer roller 9a, and is borne on the peripheral surface of the development roller 9a as the developer 9a is rotated. Then, as the development roller 9a is rotated further, the magnetic

developer on the development roller 9a is scraped by the development blade 9d. As a result, an even layer of the magnetic developer is formed on the peripheral surface of the development roller 9a.

5 **[0058]** The first and second electrodes 81 and 82 are positioned so that the excessive developer scraped away from the development roller 9a enters between them.

**[0059]** The dielectric constant of developer is greater than that of air. Therefore, when there is developer between the first and second electrodes 81 and 82, the electrostatic capacity between the two electrodes is greater than when not. In other words, when a sufficient amount of developer is in the development chamber 9A, a larger electrostatic capacity is provided between them than when not, because, when a sufficient amount of developer is in the development chamber 9A, the aforementioned developer scraped away from the development roller 9a continuously enters between the first and second electrodes 81 and 81. Then, as the developer in the development chamber 9A is consumed, the amount of the developer which enters between the electrodes 81 and 82 gradually decreases, which in turns reduces the electrostatic capacity between them. Thus, the developer amount detecting apparatus continuously detects the developer amount by detecting the change in the electrostatic capacity between the two electrodes. Figure 7 schematically shows this concept, which will be described later in detail.

30 **[0060]** In order to improve the accuracy with which the developer amount is continuously detected, all that is necessary is to increase the amount of change in the aforementioned electrostatic capacity, by increasing the sizes of the first and second electrodes 81 and 82. In particular, it is desired that the widths of the opposing surfaces of the first and second electrodes 81 and 83 are rendered greater than the distance between the two electrodes.

35 **[0061]** Referring to Figure 11 - 18, which will be helpful to better understand this embodiment, the first and second electrodes 81 and 82 in this embodiment are long and narrow members which extend in the longitudinal direction of the development roller 9a. They are formed of electrically conductive material such as stainless steel (SUS), iron, phosphor bronze, aluminum, electrically conductive resin, and the like, which are identical in terms of electrode function. However, in this embodiment, nonmagnetic metallic material such as nonmagnetic SUS was employed to prevent the electrode material from affecting developer circulation.

40 **[0062]** More specifically, in this embodiment, the first electrode 81 was formed of nonmagnetic SUS, and was 14 mm in width (W1), and 0.3 mm in thickness (t1). The second electrode 82 was formed of nonmagnetic SUS, and was 17 mm in width (W2), and 0.5 mm in thickness (t2). Arranging these electrodes along and in parallel to the development roller 9a in the longitudinal direction produced good results. The configurations of the elec-

trodes 81 and 82 need not be limited to particular one. However, arranging the electrodes 81 and 82 non-parallel so that the gap between the two electrodes becomes wider on the side from which the developer enters than on the inward side 85, as shown in Figure 3, provides good results.

**[0063]** Further, in order to increase the surface areas of the electrodes 81 and 82, the electrodes 81 and 82 may be formed on a corrugated, or embossed sheet of material, as shown in Figure 8. If it is impossible to secure a space for larger electrodes, because of design related reasons, or if it is desired to reduce the cost, either the first electrode 81 or the second electrode 82 may be formed in the form of a round rod as illustrated in Figures 9 and 10, which show the examples of such arrangement, and in which the first and second electrodes, respectively, are in the form of a round rod. Although the number of the rod in the examples illustrated in Figures 9 and 10 is singular, it may be plural.

**[0064]** Next, the positioning of the electrodes 81 and 82 in the longitudinal direction will be described. In terms of the longitudinal direction of the development roller 9a, the first and second electrodes 81 and 82 may be extended to a length approximately the same as the length of the image formation range, to increase the aforementioned electrostatic capacity so that the detection accuracy is improved. When the detection accuracy is of somewhat less concern, a pair of narrower electrodes, in terms of the longitudinal direction, may be disposed at either the center, or figure, portion of the image formation range to reduce the cost. In the case of such an arrangement, however, it is not possible to detect whether or not the developer is unevenly distributed in terms of the longitudinal direction. In order to solve such a problem, it is desired that a combination of narrow electrodes 81 and 82 be positioned at each of a plurality of locations; for example, the center and both fingers as shown in Figure 12.

**[0065]** Next, referring to Figure 13 - 16, the developer circulation within the development chamber 9A will be described.

**[0066]** When a process cartridge, more specifically, the developing apparatus portion of the process cartridge, in accordance with the present invention, is used for the first time, no developer is present between the first and second electrodes 81 and 82, although a sufficient amount of developer T is present in the development chamber 9A. In this situation, first, the developer T in the development chamber 9A is sent toward the development roller 9a by the stirring member 9e, and then, is attracted to the peripheral surface of the development roller 9a. Then, as the development roller 9a is rotated, the developer is borne on the peripheral surface of the development roller 9a. As the development roller 9a is rotated further, the developer on the peripheral surface of the development roller 9a is leveled, that is, the excess amount of the developer on the peripheral surface of the development roller 9a is scraped away, and as it

is scraped away, it enters between the first and second electrodes 81 and 82, as illustrated in Figure 13.

**[0067]** As the developer T continues to enter into the gap between the first and second electrodes 81 and 82, the gap is filled with the developer T which enters the gap, as illustrated in Figure 14. At this point, however, the development chamber 9A is still full of the developer T. Therefore, once the developer T enters the gap through the entrance 84, that is, the bottom side of the gap between the electrodes 81 and 82, it is blocked by the developer T in the development chamber 9A. Therefore, it does not occur until the amount of the developer T in the development chamber 9A reduces by a substantial amount that the developer T between the electrodes 81 and 82 free falls out of the gap between the two electrodes due to gravity or the like. In other words, when there is a sufficient amount of the developer T in the development chamber 9A, the gap between the first and second electrodes 81 and 82 is filled when the developer T, and therefore, the electrostatic capacity between the two electrodes is high.

**[0068]** Referring to Figure 15, as the amount of the developer T in the developer container 11A and development chamber 9A reduces due to the developer consumption, the portion of the developer which has been blocking the entrance (also, exit) 84 moves away from the entrance 84, allowing the developer T between the first and second electrodes 81 and 82 to free fall in the gravity direction due to its own weight. Some portion of the developer T which free falls may be attracted to the development roller 9a by the magnetic force as it falls, whereas the other may simply fall all the way to join the rest of the developer T in the development chamber 9A to be supplied again to the development roller 9a. Also, in certain class the developer T between the two electrodes is caused to directly return to the peripheral surface of the development roller 9a by the magnetic force.

**[0069]** In the situation illustrated in Figure 15, the amount of the developer in the development chamber 9A has become small enough to allow the developer between the electrodes 81 and 82 to come out from between them. However, the developer still remains in the development chamber 9A by an amount sufficient to make it necessary for the developer to be scraped away from the development roller 9a by the development blade 9b to be supplied into the gap between the first and second electrodes 81 and 82, and therefore, the amount of the developer between the electrodes 81 and 82 gradually reduces in accordance with the amount of the developer remaining in the development chamber 9A.

**[0070]** In the last stage of toner consumption in the process cartridge B, that is, after the developer in the developer container 11A and development chamber 9A has been virtually entirely consumed, the developer which remains adjacent to the tip of the development blade 9d for scraping away the excess amount of the developer layer on the peripheral surface of the devel-

opment roller 9a, that is, the developer remaining between the development roller 9a and first electrode 82 is consumed until the developer is completely depleted (END state). During this stage, the resultant prints tend to suffer from white spots.

**[0071]** As is evident from the above description, according to this embodiment, the amount of the developer in the development chamber 9A is determined by measuring the amount of the developer between the first and second electrodes 81 and 82, which can be continuously detected by measuring the electrostatic capacity between the electrodes 81 and 82.

**[0072]** Also according to this embodiment, the structural configuration adjacent to the electrodes 81 and 82 is such that the gap between the first and second electrodes 81 and 82 is provided with no opening at the inward end 85; the gap is provided with only one opening 84, which serves as the entrance as well as the exit. Therefore, widening the gap between the electrodes 81 and 82, on the side of the developer entrance 84 (also, exit), as described above, is effective to allow the developer to easily enter, or come out from, between the two electrodes.

**[0073]** However, if the amount of the developer scraped away from the peripheral surface of the development roller 9a by the development blade 9b per unit of time increases because of the increase in the rotational speed of the development roller 9a, or the like, the amount of the developer entering between the first and second electrodes 81 and 82 also increases, and sometimes, the developer becomes packed herein. If this packing occurs, the developer between the electrodes 81 and 82 cannot circulate, and in this situation, the self weight of the developer, and/or the magnetic force, is not large enough to cause the packed developer to free fall from between the two electrodes, and therefore, the electrostatic capacity between the two electrodes 81 and 82 does not change, which makes it impossible to detect the developer amount. This phenomenon is most likely to occur under a highly humid ambience in which it is easier for the developer to absorb moisture.

**[0074]** Figure 17 depicts a structural configuration as a solution to the above described problem of developer packing, according to which an opening 85a, i.e., an exit, is provided, in addition to the opening 84, i.e., the entrance-exit, on the most inward side 85 of the gap between the electrodes 81 and 82, to allow the developer to pass between the electrodes 81 and 82, so that the developer which enters the gap between the two electrodes does not become packed therein.

**[0075]** Next, the structure for attaching the first and second electrodes 81 and 82 to the developing apparatus portion of the process cartridge B will be described.

**[0076]** The developer amount detecting portion 80 comprising the first and second electrodes 81 and 82 determines the developer amount by detecting the electrostatic capacity between the two electrodes 81 and 82. Therefore, the positional accuracy of the electrodes is

extremely important. Further, since the primary object of the present invention is to accurately predict the time when toner depletion, which results in various white spots, occurs, the electrodes 81 and 82 should be positioned in the adjacency of the development roller 9a where the developer remains until it is depleted.

**[0077]** Thus, in this embodiment, the first and second electrodes 81 and 82 are attached to the development unit frame 12, as shown in Figure 18. As for the means for attaching the first and second electrodes 81 and 82, screws, adhesive, crimping, insert molding, or the like, may be used. With the employment of the above described structural arrangement, the electrodes 81 and 82 can be accurately positioned so that the distance between the first and second electrodes 81 and 82 is precisely set. Further, the positioning of the first and second electrodes 81 and 82 in the adjacency of the development roller 9a makes it possible to very closely detect the time when the developer runs out.

**[0078]** The first and second electrodes 81 and 82 in this embodiment are formed, of nonmagnetic SUS, independently from the development unit frame 12, and then, are attached thereto with an appropriate means, as described above. However, the electrodes 81 and 82 may be directly formed on the development unit frame 12 with the use of such a process as vapor deposition or printing, or may be built into the development unit frame 12, as electrically conductive portions, with the use of a combination of electrically conductive resin and two color molding. Compared to the design in this embodiment in which the electrodes and development unit frame are manufactured independently from each other, these alternative designs are much smaller in terms of attachment error and/or component size error, and therefore, their employment can improve the positioning accuracy for the electrodes.

**[0079]** Further, when necessary, for example, in a case that the development unit frame 12 is small, the design of the process cartridge B may be modified so that the first and second electrodes 81 and 82 are attached to the front wall 11a of the developer container 11A, as shown in Figure 19. In this case, the electrodes 81 and 82 can be accurately positioned.

**[0080]** Further, the process cartridge B design may be modified as shown in Figure 20. In this case, the second electrode 82 is attached to the development unit frame 12, and the first electrode 81 is attached to the front wall 11a of the developer container 11A, so that the first and second electrodes 81 and 82 oppose each other as the development unit frame 12 is joined with the developer container 11A. This arrangement affords more latitude in terms of the frame structure design for the process cartridge B.

**[0081]** In the preceding portions of this specification, the structural arrangement for continuously detecting the developer amount was described with reference to a case in which magnetic developer was used as the developer for the process cartridge B. However, the

present invention is also applicable to various process cartridges comprising a developing apparatus portion which employs nonmagnetic developer.

**[0082]** In the case of a developing apparatus structure which employs nonmagnetic developer, a developer coating roller 86 is used as a means for supplying the development roller 9a with the developer. The roller 86 is an elastic member formed of sponge or the like, and is rotated in the counter direction to the development roller 9a, in contact with the development roller 9a. The developer is coated on the development roller 9a by the electrostatic force (measured in coulomb) generated by the contact. Immediately prior to the complete depletion of the developer T, the developer T remains above the interface between the development roller 9a and developer coating roller 86. Thus, positioning the first and second electrodes 81 and 82 in the adjacency of the area above this interface makes it possible to continuously detect the developer amount as in the process cartridge B which employs magnetic developer.

**[0083]** Next, referring to Figures 4 - 6, this embodiment of the present invention will be described regarding the structural arrangement for connecting the electrodes 81 and 82 with the electrical contacts on the electrophotographic image forming apparatus main assembly 14 side.

**[0084]** In this embodiment, the first and second electrodes 81 and 82 are provided with projections 81a and 82a, respectively, as shown in Figure 6. These projections 81a and 82a are inserted in the correspondent through holes 12a and 12b with which the development unit frame 12 is provided, when the first and second electrodes 81 and 82 are attached to the development unit frame 12.

**[0085]** The development unit frame 12 is provided with a holder 90, which is fixed to the development unit frame 12, at one of the longitudinal end. The holder 90 rotatively supports the development roller 9a with the interposition of a bearing. The holder 90 is provided with a first electrical contact 91 and a second electrical contact 92. The contact portions 91a and 92a, that is, the free ends, of the first and second electrical contacts 91 and 92, respectively, become connected to the aforementioned projections 81a and 82a of the first and second electrodes 81 and 82, respectively, as the holder 90 is fixed to the development unit frame 12, at one of the longitudinal ends.

**[0086]** The contact portions 91b and 92b, that is, the ends opposite to the aforementioned free ends, of the first and second electrical contacts 91 and 92 are fixed to the holder 90, being exposed from the outward surface of the holder 90 so that, as the process cartridge B is installed into the apparatus main assembly 14, they become electrically connected to the contacts 17 and 18 (Figure 5), respectively, positioned in the apparatus main assembly 14.

**[0087]** With the provision of the above described structural configuration, as the process cartridge B is in-

stalled into the main assembly 14 of an electrophotographic image forming apparatus, voltage is applied from the electrophotographic image forming apparatus main assembly 14 to the first electrode 81 through the first electrical contact 91, and the voltage induced in the second electrode 82, which is in accordance with the electrostatic capacity between the electrodes 81 and 82, is outputted to the electrophotographic image forming apparatus main assembly 14 through the second electrical contact 92. Of course, it is possible that voltage be applied from the electrophotographic image forming apparatus main assembly 14 to the second electrode 82 through the first electrical contact 92, and the voltage induced in the first electrode 81 be outputted to the electrophotographic image forming apparatus main assembly 14 through the second electrical contact 92.

**[0088]** Next, referring to Figure 22, an embodiment of the above described principle in the form of a developer amount detecting apparatus will be described further. Figure 22 is an example of a diagram of a developer amount detection circuit, inclusive of the connection between the circuit and the developer amount detecting portion 80 provided with the first and second electrodes 81 and 82, in the image forming apparatus.

**[0089]** The detecting portion 80, which has an electrostatic capacity  $C_a$  which fluctuates in accordance with the change in the developer amount, comprises an input electrode as an impedance element, that is, the first electrode 81 in this embodiment, and an output electrode, that is, the second electrode 82 in this embodiment. The input electrode is connected to a development bias circuit 101, as a development bias applying means, through the first electrical contact 91, and the output electrode is connected to the control circuit 102 of the developer amount detection circuit 100 through the second electrical contact 92. A referential capacity element ( $C_b$ ) is also connected to the development bias circuit 101, and establishes a reference voltage  $V_1$  for detecting the amount of the remaining developer, with the use of the AC current  $I_1$  applied through the bias circuit 101. It is obvious that, as the process cartridge B is installed into the apparatus main assembly 14, the contact 19 (unillustrated in Figure 5) disposed in the apparatus main assembly 14 makes electrical contact with the contact portion 93a of the electrical contact 93 of the development roller 9a, and as a result, development bias is applied to the development roller 9a from the bias circuit 101.

**[0090]** The control circuit 102 establishes the reference voltage  $V_1$  by adding the amount  $V_2$  of the voltage drop caused by an AC current  $I_1'$ , that is, a current shunted by a volume  $VR_1$  from the AC current  $I_1$  applied to the reference impedance element, and a resistor  $R_2$ , to voltage  $V_3$  established by resistors  $R_3$  and  $R_4$ .

**[0091]** Therefore, an AC current  $I_2$  applied to the developer amount detecting portion 80 is inputted into an amplifier 103, and then, is outputted as a voltage  $V_4$  ( $V_1 - I_2 \times R_5$ ) which represents the amount of the remaining



developer. Then, its output value is used as the value of the detected amount of the remaining developer.

**[0092]** The image forming apparatus in this embodiment prompts a user to prepare a new process cartridge or a developer supply cartridge, by displaying the consumed amount of the developer determined based on the information obtained by continuously detecting the developer amount between the first and second electrodes 81 and 82, and also prompts a user to exchange the process cartridge, or replenish the process cartridge with a fresh supply of developer, by displaying "OUT OF DEVELOPER" in accordance with the detected depletion of the developer by the aforementioned continuous detection.

**[0093]** Regarding the method for displaying the developer amount, the information obtained by the aforementioned developer amount detecting apparatus is displayed on the monitor screen of a user's personal computer or the like, as shown in Figures 23 and 24; a user is informed of the developer amount by observing the point on a gauge 42 indicated by a hand (needle) 41 which moves in accordance with the developer amount.

**[0094]** The image forming apparatus main assembly itself may be provided with a display panel, such as an LED based display panel 43 shown in Figure 25, which flashes at a position correspondent to the developer amount.

## Embodiment 2

**[0095]** Figure 26 depicts another embodiment of the present invention. The developing apparatus in the process cartridge B in this embodiment is provided with a third electrically conductive portion (electrode) 83 as the measuring member for the developer amount detecting portion 80. Otherwise, it is substantially the same in structure as the one in the process cartridge B in the first embodiment. Thus, the structures and components in this embodiment which are the same as those in the first embodiment will be given the same referential numbers as those given to the correspondent structures and components in the first embodiment, and their detailed descriptions will be omitted.

**[0096]** In other words, this embodiment is a duplicate of the first embodiment in terms of the first and second electrically conductive portions (electrodes) 81 and 82, their structures and positioning, developer circulation between the electrodes 81 and 82, structures surrounding the electrodes 81 and 82, methods for attaching the electrodes 81 and 82, and the like. Therefore, the descriptions for the structures and functions of the duplicate portions will be omitted.

**[0097]** The primary object of the process cartridge structure in this embodiment is to accurately detect the point in time immediately before the printing errors in the form of white spots begin to be seen in finished prints. All that is necessary to accomplish this object is to detect the developer amount in the area in the process car-

tridge B, from which the last supply of the developer is consumed. Thus, in this embodiment, the developer amount in the immediate adjacencies of the second and third electrodes 82 and 83, and the development roller 9a, is detected as described in the description of the first embodiment, regarding the developer circulation.

**[0098]** In other words, in the case of the developer amount detecting apparatus in this embodiment, which is illustrated in Figure 26, not only the first and second electrodes 81 and 82 are positioned as those in the first embodiment, but also, an additional electrodes, i.e., the third electrode 83, is positioned along the development roller 9a. The third electrode 83 is disposed much closer to the development roller 9a than the first electrode 83.

**[0099]** With the provision of the above described structural arrangement, as voltage is applied to the first electrode 81, static electricity is induced between the first and second electrodes 81 and 82 by an amount of Ca, and at the same time, static electricity is also induced between the development roller 9a and third electrode 83 by the development bias applied to the development roller 9a, by an amount of Cc. The development amount is determined by measuring these electrostatic capacities Ca and Cc.

**[0100]** Illustrated in Figure 27 is an example of a developer amount detection circuit in this embodiment. The overall circuit structure is substantially the same as the developer amount detection circuit in the first embodiment given in Figure 22, with one exception that the third electrode 83 is disposed in a way to oppose the development roller 9a so that static electricity is induced between the development roller 9a and third electrode 83 by the amount of Cc.

Therefore, the detailed description for this embodiment will be omitted.

**[0101]** Referring to Figure 27, the developer amount detection circuit in this embodiment is provided with a contact 91 to be connected with the electrode 17 of the electrophotographic image forming apparatus main assembly 14 to apply voltage to the first electrode 81, and a contact 93 to be connected with the electrode 19 of the apparatus main assembly 14 to apply the development bias to the development roller 9a. The separate provision of these contacts 91 and 93 affords more latitude in design.

**[0102]** Further, the voltage to be applied to the first electrode 81 is provided from the development bias circuit 101, eliminating the need for an additional power source. Therefore, cost increase can be avoided.

**[0103]** Further, the contacts are in the form of a single piece, and therefore, there is no stray capacitance, assuring that the electrostatic capacity is accurately measured.

**[0104]** As described above, in this embodiment, the developer amount in the process cartridge B is accurately determined by continuously detecting the decrease in the amount of the developer between the electrodes 81 and 82, and the "END" of the developer supply

in the process cartridge B is accurately detected by detecting the amount of the developer between the development roller 9a and electrode 83. The relationship between the developer amount and the output of the toner amount detection circuit is graphically shown in Figure 28, (a), (b) and (c).

[0105] Again referring to Figure 27, the first electrostatic capacity element (Ca) provided by the first and second electrodes 81 and 82, and the second electrostatic capacity element (Cc) provided by the development roller 9a and third electrode 83, are connected in parallel, reducing the number of the contacts in the image forming apparatus main assembly 14 and process cartridge B. Therefore, the process cartridge B in this embodiment is lower in cost.

[0106] Lengthy routing of wiring increases the chance that static electricity is induced between the adjacent portions of wiring, which in turns reduces detection accuracy. Thus, reducing the distance electric wiring is routed leads to improvement in detection accuracy. Therefore, the second and third electrodes 82 and 83 are desired to be wired as shown in Figure 27. Preferably, the second and third electrodes 82 and 83 are integrally formed to minimize the wiring, so that detection accuracy is further improved. In this case, the third electrode 83 is bent so that the bent portion of the electrode 83 extends away from the second electrode 82, reducing the distance between the third electrode 83 and development roller 9a as described above.

### Embodiment 3

[0107] Figure 30 depicts another embodiment of the present invention in the form of a developing apparatus cartridge C.

[0108] The developing apparatus C in this embodiment is in the form of a cartridge comprising a developer carrier such as a development roller 9a, a development chamber 9A which contains toner to supply the developer carrier with developer, and a plastic development unit frame 11 in which the developer carrier and development chamber 9A are contained. In other words, the developing apparatus C in this embodiment is considered to be a cartridge version of the developing apparatus portion of the process cartridge B in the first and second embodiment described above, that is, a cartridge formed by eliminating the photosensitive drum 7, charging means 8, and cleaning means 10, from the process cartridge B. Therefore, all the descriptions given to the structures of the developing apparatus portion and developer amount detecting means portion, in the first and second embodiments, also apply to the developing apparatus in this embodiment. Thus, the description of the structure and function of the developing apparatus in this embodiment will be omitted here, by referring to the preceding descriptions of the first and second embodiment.

[0109] Needless to say, the developing apparatus in

this embodiment may be provided with the third electrode 83.

[0110] As is evident from the descriptions of the preceding embodiments, according to the present invention, the amount of the remaining developer can be accurately and continuously detected.

[0111] In the preceding embodiments, the amount of the remaining developer can be continuously detected while the amount of the remaining developer is in a range from approximately 30 % down to 0 %, provided that the entire amount of the developer contained in the developer container before a process cartridge is put to use for the first time is 100 %. However, the application of the present invention does not need to be limited to the preceding embodiment. For example, modifications may be made so that the amount of the remaining developer in the developer container can be continuously detected in a range from 50 % down to 0 %, or from 40 % down to 0 %. It should be noted here that "0%" does not mean a state of a process cartridge in which the developer has been completely depleted; it also includes another state of a process cartridge in which the amount of the developer in the process cartridge has decreased to a point close enough to disable the image forming apparatus to form images with a predetermined level of quality (development quality).

### [Effects of Invention]

[0112] As described above, according to the first aspect of the present invention, a developing apparatus, a process cartridge, or an electrophotographic image forming apparatus, comprises: a first electrically conductive portion; a second electrically conductive portion opposing the first electrically conductive portion; a first electrical contact for receiving the voltage to be applied to the first electrically conductive portion, from the electrophotographic image forming apparatus main assembly; and a second electrical contact for transmitting to the electrophotographic image forming apparatus main assembly, electrical signals generated in accordance with the electrostatic capacity provided between the first and second electrically conductive portions as voltage is applied to the first electrically conductive portion, in order to enable the electrophotographic image forming apparatus main assembly to detect the amount of the remaining developer. According to the second aspect of the present invention, a developing apparatus, a process cartridge, and an electrophotographic image forming apparatus, comprises: a first electrically conductive portion; a second electrically conductive portion opposing the first electrically conductive portion; a first electrical contact for receiving the voltage to be applied to the first electrically conductive portion, from the electrophotographic image forming apparatus main assembly; a third electrically conductive portion for inducing static electricity between the developer carrying member and itself as voltage is applied to the third electrically con-

ductive portion from the electrophotographic image forming apparatus main assembly; and a second electrical contact for transmitting to the electrophotographic image forming apparatus main assembly, compound electrical signals comprising electrical signals generated in accordance with the electrostatic capacity provided between the first and second electrically conductive portions as voltage is applied to the first electrically conductive portion, and electrical signals generated in accordance with the electrostatic capacity provided between the developer carrying member and third electrically conductive portion as voltage is applied to the developer carrying member, in order to enable the electrophotographic image forming apparatus main assembly to detect the amount of the remaining developer. Therefore, the amount of the remaining developer in the development chamber can be continuously detected as the developer is consumed. Further, the measurement errors, which occur when detecting the amount of the remaining developer on the basis of the fluctuation in the electrostatic capacity between two electrodes, in an unstable ambience, can be eliminated to reduce overall detection error. Therefore, a developing apparatus, a process cartridge, and an electrophotographic image forming apparatus, can be drastically improved in terms of convenience.

[0113] Also, according to the first aspect of the present invention, a development unit frame comprises: a portion for supporting a developer carrying member for conveying developer to an electrophotographic photosensitive member to develop an electrostatic latent image formed on the electrophotographic photosensitive member; a portion for supporting a regulating member which regulates the amount of the developer allowed to remain on the peripheral surface of the developer carrying member; a portion for supporting the first electrically conductive portion; and a portion for supporting the second electrically conductive portion in such a way that the second electrically conductive portion opposes the first electrically conductive portion supported by the first electrically conductive portion supporting portion. Also, according to the second aspect of the present invention, a development unit frame comprises: a portion for supporting a developer carrying member for conveying developer to an electrophotographic photosensitive member to develop an electrostatic latent image formed on the electrophotographic photosensitive member; a portion for supporting a regulating member which regulates the amount of the developer allowed to remain on the peripheral surface of the developer carrying member; a portion for supporting the first electrically conductive portion; and a portion for supporting the second electrically conductive portion in such a way that the second electrically conductive portion opposes the first electrically conductive portion supported by the first electrically conductive portion supporting portion; and a portion for supporting the third electrically conductive portion in such a way that the third electrically

cally conductive portion opposes the developer carrying member supported by the developer carrying member supporting portion. Therefore, it is assured that a developer amount detecting means or the like, which can continuously detect the amount of the developer remaining in the development chamber as the developer is consumed, is properly attached to the aforementioned developing apparatus, process cartridge, or electrophotographic image forming apparatus.

[0114] As is evident from the above description of the preferred embodiments of the present invention, according to the present invention, it is assured that the amount of the remaining developer can be continuously detected.

[0115] While the invention has been described with reference to the structures disclosed herein, it is not confined to the details set forth and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

## Claims

1. A developing device for developing an electrostatic latent image formed on an electrophotographic photosensitive member, said developing device being mountable to a main assembly of an electrophotographic image forming apparatus, said developing device comprising;

a developer carrying member for feeding a developer to said electrophotographic photosensitive member to develop the electrostatic latent image formed on the electrophotographic photosensitive member;  
a first electroconductive portion;  
a second electroconductive portion for cooperating with said first electroconductive portion to provide an electrostatic capacity;  
a first electrical contact for receiving a voltage to be applied to said first electroconductive portion from the main assembly of the electrophotographic image forming apparatus;  
a second electrical contact for transmitting, to the main assembly of the electrophotographic image forming apparatus, an electric signal corresponding to an electrostatic capacity between said first electroconductive portion and said second electroconductive portion when a voltage is applied to said first electroconductive portion to detect a remaining amount of the developer by the main assembly of the electrophotographic image forming apparatus.

2. A developing device for developing an electrostatic latent image formed on an electrophotographic photosensitive member, said developing device be-

ing mountable to a main assembly of an electrophotographic image forming apparatus, said developing device comprising:

- a developer carrying member for feeding a developer to said electrophotographic photosensitive member to develop the electrostatic latent image formed on the electrophotographic photosensitive member;  
first electroconductive portion;  
a second electroconductive portion for cooperating with said first electroconductive portion to provide an electrostatic capacity;  
a first electrical contact for receiving a voltage to be applied to said first electroconductive portion from the main assembly of the electrophotographic image forming apparatus;  
a third electroconductive portion for cooperating with said developer carrying member to provide an electrostatic capacity when a voltage is applied to said developer carrying member from the main assembly of said electrophotographic image forming apparatus;  
a second electrical contact for transmitting, to the main assembly of the electrophotographic image forming apparatus, a combined electric signal of an electric signal corresponding to an electrostatic capacity between said first electroconductive portion and said second electroconductive portion when a voltage is applied to said first electroconductive portion and an electric signal corresponding to an electrostatic capacity between said developer carrying member and the third electroconductive portion when a voltage is applied to said developer carrying member, to detect a remaining amount of the developer by the main assembly of the electrophotographic image forming apparatus.
- 3. A device according to Claim 1 or 2, wherein said first electroconductive portion and second electroconductive portion are arranged in a longitudinal direction of a developer carrying member in the form of a developing roller.
- 4. A process cartridge according to Claim 1 or 2, wherein said first electroconductive portion is disposed more remote from said developer carrying member than said second electroconductive portion.
- 5. A device according to Claim 1 or 2, wherein said second electrical contact is electrically connected with said second electroconductive portion.
- 6. A device according to Claim 1 or 2, wherein the developer is fed to between said first electroconductive portion and said second electroconductive portion, and the developer fed to between said first electroconductive portion and said second electroconductive portion is retracted in an entering direction.
- 7. A device according to Claim 1 or 2, wherein the developer fed to between said first electroconductive portion and second electroconductive portion passes between said first electroconductive portion and second electroconductive portion.
- 8. A device according to Claim 1 or 2, wherein said first electroconductive portion and second electroconductive portion have a flat-plate-like shape, a gap between said first electroconductive portion and second electroconductive portion is wider at a developer entering side.
- 9. A device according to Claim 1 or 2, wherein said first electroconductive portion has a flat-plate-like shape.
- 10. A device according to Claim 1 or 2, wherein said second electroconductive portion has a flat-plate-like shape.
- 11. A device according to Claim 1 or 2, wherein said first electroconductive portion has a rod-like shape.
- 12. A device according to Claim 1 or 2, wherein said second electroconductive portion has a rod-like shape.
- 13. A process cartridge according to Claim 1, further comprising a third electroconductive portion for cooperating with said developer carrying member to provide an electrostatic capacity when a voltage is applied to said developer carrying member from a main assembly of said electrophotographic image forming apparatus.
- 14. A process cartridge according to Claim 13, wherein when the voltage is applied to said developer carrying member, an electric signal corresponding to the electrostatic capacity between said developer carrying member and said third electroconductive portion is transmitted to the main assembly of said electrophotographic image forming apparatus.
- 15. A device according to Claim 1 or 2, further comprising a magnet disposed in said developer carrying member, and said developer is a magnetic developer which is deposited on the surface of said developer carrying member.
- 16. A device according to any one of Claims 2-12, wherein said third electroconductive portion is constituted integrally.

17. A process cartridge according to Claim 16, wherein said third electroconductive portion is at an angle relative to said second electroconductive portion.

18. A device according to Claim 2, 16 or 17, wherein said third electroconductive portion is disposed opposed to said developer carrying member.

19. A device according to Claim 2, 16, 17 or 18, wherein said third electroconductive portion is disposed closer to said developer carrying member than said first electroconductive portion and said second electroconductive portion.

20. A process cartridge detachably mountable to a main assembly of an electrophotographic image forming apparatus, said process cartridge comprising:

(a) electrophotographic photosensitive member; and

(b) a developing device for developing an electrostatic latent image formed on said electrophotographic photosensitive member, said developing device including;

a developer carrying member for feeding a developer to said electrophotographic photosensitive member to develop the electrostatic latent image formed on the electrophotographic photosensitive member;  
a first electroconductive portion;  
a second electroconductive portion for cooperating with said first electroconductive portion to provide an electrostatic capacity;  
a first electrical contact for receiving a voltage to be applied to said first electroconductive portion from the main assembly of the electrophotographic image forming apparatus;  
a second electrical contact for transmitting, to the main assembly of the electrophotographic image forming apparatus, an electric signal corresponding to an electrostatic capacity between said first electroconductive portion and said second electroconductive portion when a voltage is applied to said first electroconductive portion to detect a remaining amount of the developer by the main assembly of the electrophotographic image forming apparatus.

21. A process cartridge detachably mountable to a main assembly of an electrophotographic image forming apparatus, said process cartridge comprising:

(a) electrophotographic photosensitive mem-

ber; and

(b) a developing device for developing an electrostatic latent image formed on an electrophotographic photosensitive member, said developing device including;

a developer carrying member for feeding a developer to said electrophotographic photosensitive member to develop the electrostatic latent image formed on the electrophotographic photosensitive member;  
a first electroconductive portion;  
a second electroconductive portion for cooperating with said first electroconductive portion to provide an electrostatic capacity;  
a first electrical contact for receiving a voltage to be applied to said first electroconductive portion from the main assembly of the electrophotographic image forming apparatus;

a third electroconductive portion for cooperating with said developer carrying member to provide an electrostatic capacity when a voltage is applied to said developer carrying member from the main assembly of said electrophotographic image forming apparatus;

a second electrical contact for transmitting, to the main assembly of the electrophotographic image forming apparatus, a combined electric signal of an electric signal corresponding to an electrostatic capacity between said first electroconductive portion and said second electroconductive portion when a voltage is applied to said first electroconductive portion and an electric signal corresponding to an electrostatic capacity between said developer carrying member and the third electroconductive portion when a voltage is applied to said developer carrying member, to detect a remaining amount of the developer by the main assembly of the electrophotographic image forming apparatus.

22. A process cartridge according to Claim 20 or 21, wherein said first electroconductive portion and second electroconductive portion are arranged in a longitudinal direction of a developer carrying member in the form of a developing roller.

23. A process cartridge according to Claim 20 or 21, wherein said first electroconductive portion is disposed more remote from said developer carrying member than said second electroconductive portion.

24. A process cartridge according to Claim 20 or 21,

wherein said second electrical contact is electrically connected with said second electroconductive portion.

25. A process cartridge according to Claim 20 or 21, wherein the developer is fed to between said first electroconductive portion and said second electroconductive portion, and the developer fed to between said first electroconductive portion and said second electroconductive portion is retracted in an entering direction. 5
26. A process cartridge according to Claim 20 or 21, wherein the developer fed to between said first electroconductive portion and second electroconductive portion passes between said first electroconductive portion and second electroconductive portion. 10
27. A process cartridge according to Claim 20 or 21, wherein said first electroconductive portion and second electroconductive portion have a flat-plate-like shape, a gap between said first electroconductive portion and second electroconductive portion is wider at a developer entering side. 15
28. A process cartridge according to Claim 20 or 21, wherein said first electroconductive portion has a flat-plate-like shape. 20
29. A process cartridge according to Claim 20 or 21, wherein said second electroconductive portion has a flat-plate-like shape. 25
30. A process cartridge according to Claim 20 or 21, wherein said first electroconductive portion has a rod-like shape. 30
31. A process cartridge according to Claim 20 or 21, wherein said second electroconductive portion has a rod-like shape. 35
32. A process cartridge according to Claim 20, further comprising a third electroconductive portion for cooperating with said developer carrying member to provide an electrostatic capacity when a voltage is applied to said developer carrying member from a main assembly of said electrophotographic image forming apparatus. 40
33. A process cartridge according to Claim 20, wherein when the voltage is applied to said developer carrying member, an electric signal corresponding to the electrostatic capacity between said developer carrying member and said third electroconductive portion is transmitted to the main assembly of said electrophotographic image forming apparatus. 45
34. A process cartridge according to Claim 20 or 21, further comprising a magnet disposed in said developer carrying member, and said developer is a magnetic developer which is deposited on the surface of said developer carrying member. 50
35. A process cartridge according to any one of Claims 21-31, wherein said third electroconductive portion is constituted integrally. 55
36. A process cartridge according to Claim 35, wherein said third electroconductive portion is at an angle relative to said second electroconductive portion.
37. A process cartridge according to Claim 21, 35 or 36, wherein said third electroconductive portion is disposed opposed to said developer carrying member.
38. A process cartridge according to Claim 21, 35, 36 or 37, wherein said third electroconductive portion is disposed closer to said developer carrying member than said first electroconductive portion and said second electroconductive portion.
39. A process cartridge according to Claim 20 or 21, further comprising a charging member for charging said electrophotographic photosensitive member.
40. A process cartridge according to Claim 20, 21 or 39, further comprising a cleaning member for removing a developer deposited on said electrophotographic photosensitive member.
41. An electrophotographic image forming apparatus for forming an image on a recording material, comprising:
  - (a) electrophotographic photosensitive member;
  - (b) an electrostatic latent image forming means for forming an electrostatic latent image on said electrophotographic photosensitive member;
  - (c) a developing device for developing an electrostatic latent image formed on said electrophotographic photosensitive member, said developing device including;
    - a developer carrying member for feeding a developer to said electrophotographic photosensitive member to develop the electrostatic latent image formed on the electrophotographic photosensitive member;
    - a first electroconductive portion;
    - a second electroconductive portion for cooperating with said first electroconductive portion to provide an electrostatic capacity;
    - a first electrical contact for receiving a voltage to be applied to said first electrocon-

ductive portion from the main assembly of the electrophotographic image forming apparatus;

a second electrical contact for transmitting, to the main assembly of the electrophotographic image forming apparatus, an electric signal corresponding to an electrostatic capacity between said first electroconductive portion and said second electroconductive portion when a voltage is applied to said first electroconductive portion to detect a remaining amount of the developer by the main assembly of the electrophotographic image forming apparatus; and

said apparatus further comprising:

(d) detecting means for detecting an amount of a developer existing in said developing device on the basis of the electric signal transmitted from said second electrical contact.

42. An electrophotographic image forming apparatus for forming an image on a recording material, comprising:

(a) electrophotographic photosensitive member;

electrostatic latent image forming means for forming an electrostatic latent image on said electrophotographic photosensitive member;

(b) mounting means for mounting the process cartridge, which includes:

electrophotographic photosensitive member; and a developing device for developing an electrostatic latent image formed on an electrophotographic photosensitive member, said developing device including;

a developer carrying member for feeding a developer to said electrophotographic photosensitive member to develop the electrostatic latent image formed on the electrophotographic photosensitive member;

first electroconductive portion;

a second electroconductive portion for cooperating with said first electroconductive portion to provide an electrostatic capacity;

a first electrical contact for receiving a voltage to be applied to said first electroconductive portion from the main assembly of the electrophotographic image forming apparatus;

a third electroconductive portion for cooperating with said developer carrying member to provide an electrostatic capacity when a voltage is applied to said developer carrying member from the main assembly of said electrophotographic image forming

apparatus;

a second electrical contact for transmitting, to the main assembly of the electrophotographic image forming apparatus, a combined electric signal of an electric signal corresponding to an electrostatic capacity between said first electroconductive portion and said second electroconductive portion when a voltage is applied to said first electroconductive portion and an electric signal corresponding to an electrostatic capacity between said developer carrying member and the third electroconductive portion when a voltage is applied to said developer carrying member, to detect a remaining amount of the developer by the main assembly of the electrophotographic image forming apparatus; and

(c) detecting means for detecting an amount of a developer existing in said developing device on the basis of the electric signal transmitted from said second electrical contact.

43. An electrophotographic image forming apparatus for forming an image on a recording material, to which a process cartridge is detachably mountable, said apparatus comprising:

mounting means for detachably mounting the process cartridge, which includes:

electrophotographic photosensitive member; and

a developing device for developing an electrostatic latent image formed on said electrophotographic photosensitive member, said developing device including;

a developer carrying member for feeding a developer to said electrophotographic photosensitive member to develop the electrostatic latent image formed on the electrophotographic photosensitive member;

a first electroconductive portion;

a second electroconductive portion for cooperating with said first electroconductive portion to provide an electrostatic capacity;

a first electrical contact for receiving a voltage to be applied to said first electroconductive portion from the main assembly of the electrophotographic image forming apparatus;

a second electrical contact for transmitting, to the main assembly of the electrophotographic image forming apparatus, an electric signal corresponding to an electrostatic capacity between said first electroconductive portion and said second electroconductive portion when a voltage is applied to said first electroconductive portion to detect a remaining amount of the de-

veloper by the main assembly of the electrophotographic image forming apparatus; said apparatus;

said apparatus further comprising:

(b) electrostatic latent image forming means for forming an electrostatic latent image on said electrophotographic photosensitive member;  
(c) detecting means for detecting an amount of a developer existing in said developing device on the basis of the electric signal transmitted from said second electrical contact.

44. An electrophotographic image forming apparatus for forming an image on a recording material, to which a process cartridge is detachably mountable, said apparatus comprising:

(a) mounting means for mounting the process cartridge, which includes:

electrophotographic photosensitive member; and

a developing device for developing an electrostatic latent image formed on an electrophotographic photosensitive member, said developing device including;  
a developer carrying member for feeding a developer to said electrophotographic photosensitive member to develop the electrostatic latent image formed on the electrophotographic photosensitive member;  
first electroconductive portion;  
a second electroconductive portion for cooperating with said first electroconductive portion to provide an electrostatic capacity;  
a first electrical contact for receiving a voltage to be applied to said first electroconductive portion from the main assembly of the electrophotographic image forming apparatus;

a third electroconductive portion for cooperating with said developer carrying member to provide an electrostatic capacity when a voltage is applied to said developer carrying member from the main assembly of said electrophotographic image forming apparatus;

a second electrical contact for transmitting, to the main assembly of the electrophotographic image forming apparatus, a combined electric signal of an electric signal corresponding to an electrostatic capacity between said first electroconductive portion i and said second electroconductive portion when a voltage is applied to said first electroconductive portion and an elec-

tric signal corresponding to an electrostatic capacity between said developer carrying member and the third electroconductive portion when a voltage is applied to said developer carrying member, to detect a remaining amount of the developer by the main assembly of the electrophotographic image forming apparatus;

(b) electrostatic latent image forming means for forming an electrostatic latent image on said electrophotographic photosensitive member;  
(c) detecting means for detecting an amount of a developer existing in said developing device on the basis of the electric signal transmitted from said second electrical contact.

45. An electrophotographic image forming apparatus according to any one of Claims 41-44, wherein said developer amount detecting means detects substantially real time the amount of said developer in said developing device, and the result of the detection is continuously displayed.

46. An electrophotographic image forming apparatus according to any one of Claims 41-44, wherein said developer amount detecting means detects substantially real time the amount of said developer in said developing device, and the result of the detection is continuously displayed.

47. A developing frame for a process cartridge which is detachably mountable to a main assembly of an electrophotographic image forming apparatus, said developing frame comprising:

a developer carrying member mounting portion for feeding a developer to said electrophotographic photosensitive member to develop an electrostatic latent image formed on an electrophotographic photosensitive member;  
a first electroconductive portion mounting portion for mounting a first electroconductive portion;  
a second electroconductive portion mounting portion for mounting a second electroconductive portion for cooperation with first electroconductive portion mounted to said first electroconductive portion mounting portion.

48. A developing frame for a process cartridge detachably mountable to a main assembly of an electrophotographic image forming apparatus, said developing frame comprising:

a developer carrying member mounting portion for mounting a developer carrying member for feeding a i developer to said electrophoto-



graphic photosensitive member to develop an  
electrostatic latent image formed on an electro-  
photographic photosensitive member;  
a first electroconductive portion mounting por- 5  
tion for mounting a first electroconductive por-  
tion;  
a second electroconductive portion mounting  
portion for mounting second electroconductive  
portion for cooperation with the first electrocon- 10  
ductive portion mounted to said first electrocon-  
ductive portion mounting portion to provide an  
electrostatic capacity;  
a third electroconductive portion mounting por-  
tion for mounting a third electroconductive por- 15  
tion so as to oppose to a developer carrying  
member mounted to said developer carrying  
member mounting portion.

49. A developing frame according to Claim 47 or 48,  
wherein said first electroconductive portion mount- 20  
ing portion and second electroconductive portion  
mounting portion are mounted such that first elec-  
troconductive portion and second electroconduc-  
tive portion are disposed to permit the developer to  
be feed between said first electroconductive portion 25  
and said second electroconductive portion mount-  
ed to said first electroconductive portion mounting  
portion and second electroconductive portion  
mounting portion.

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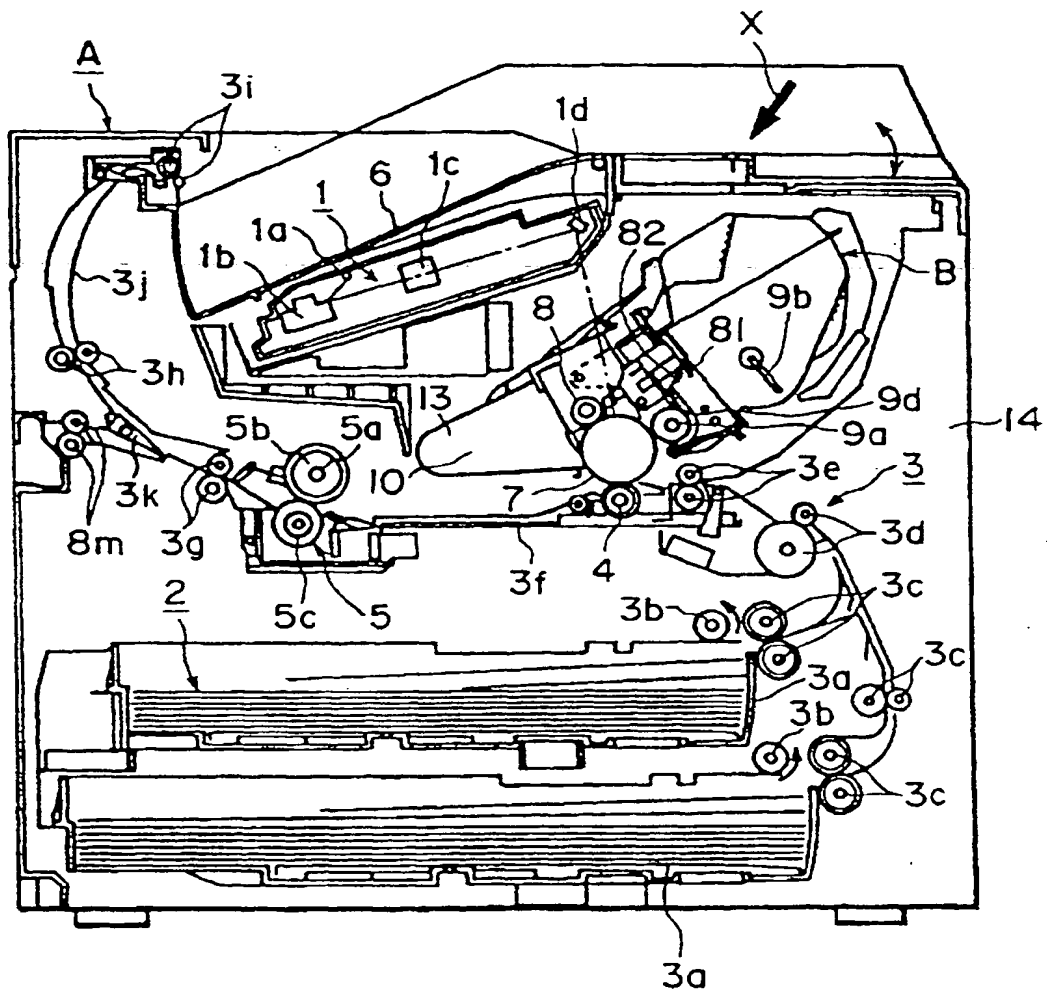


FIG. 1

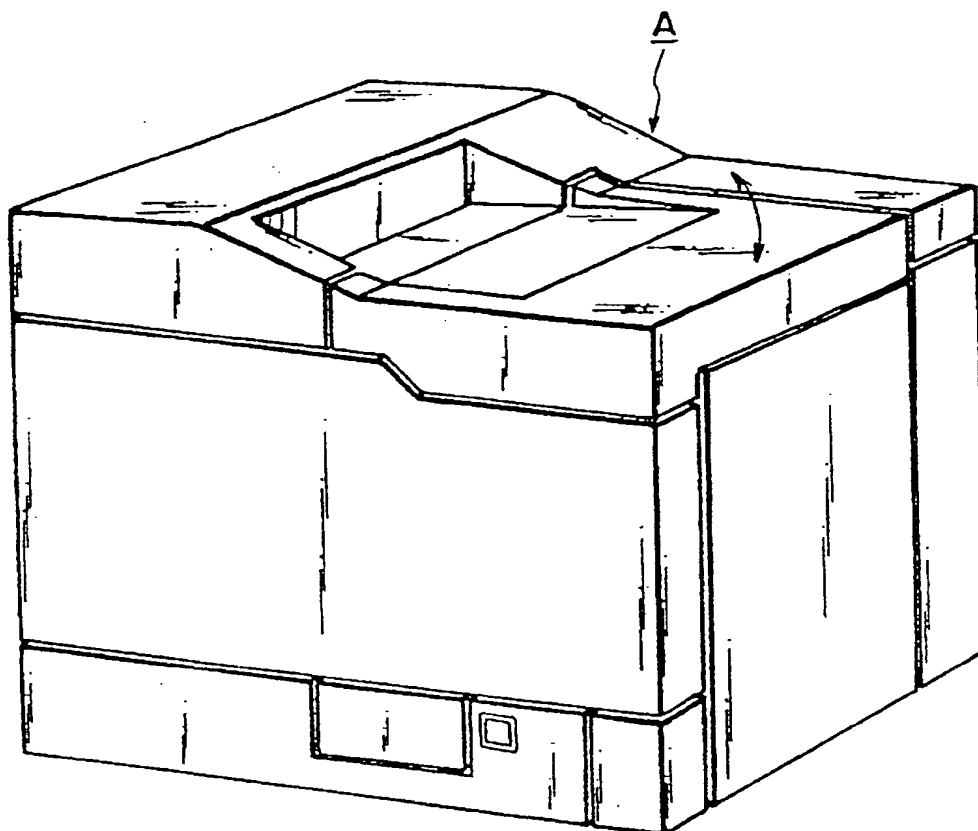


FIG. 2

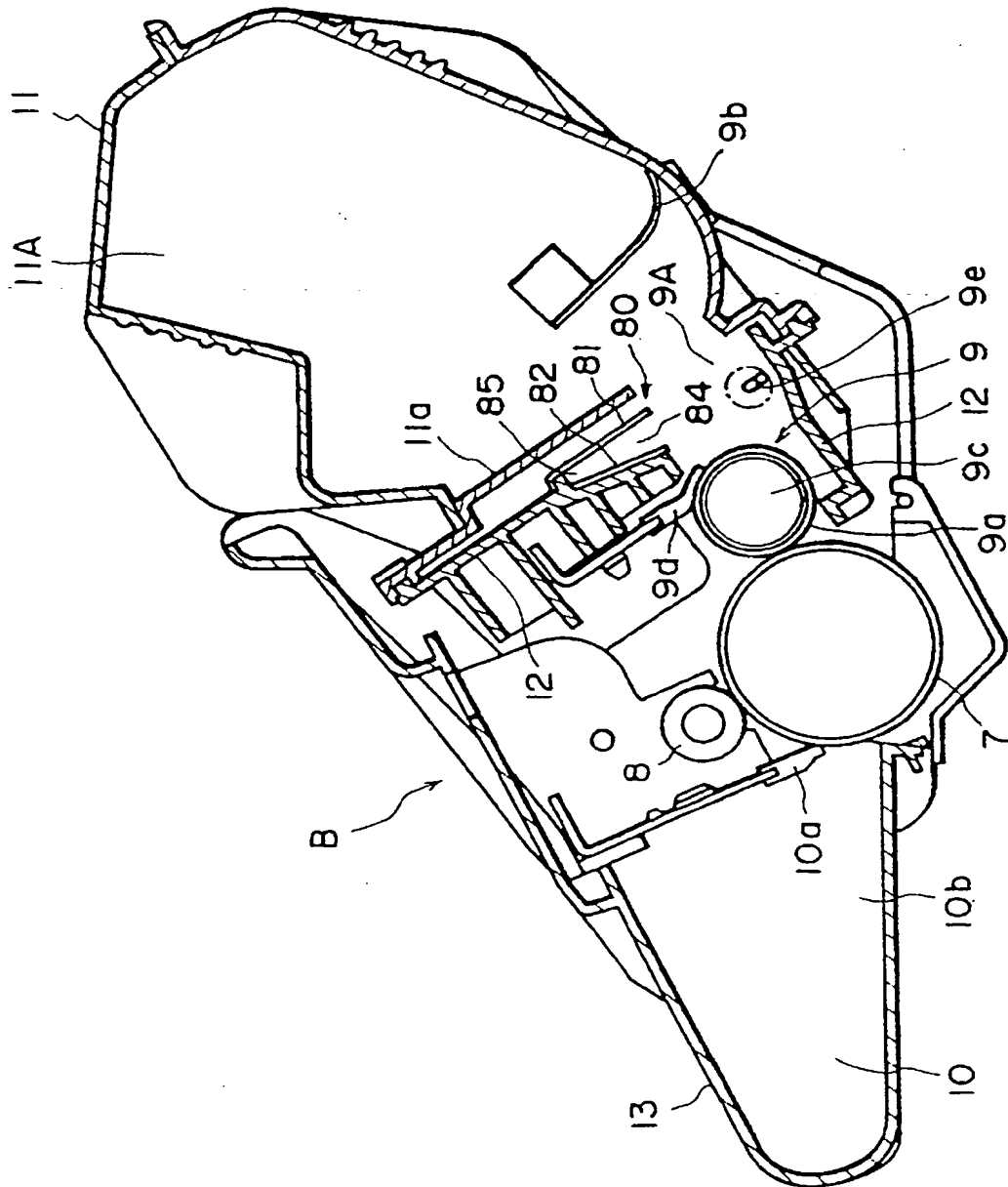


FIG. 3

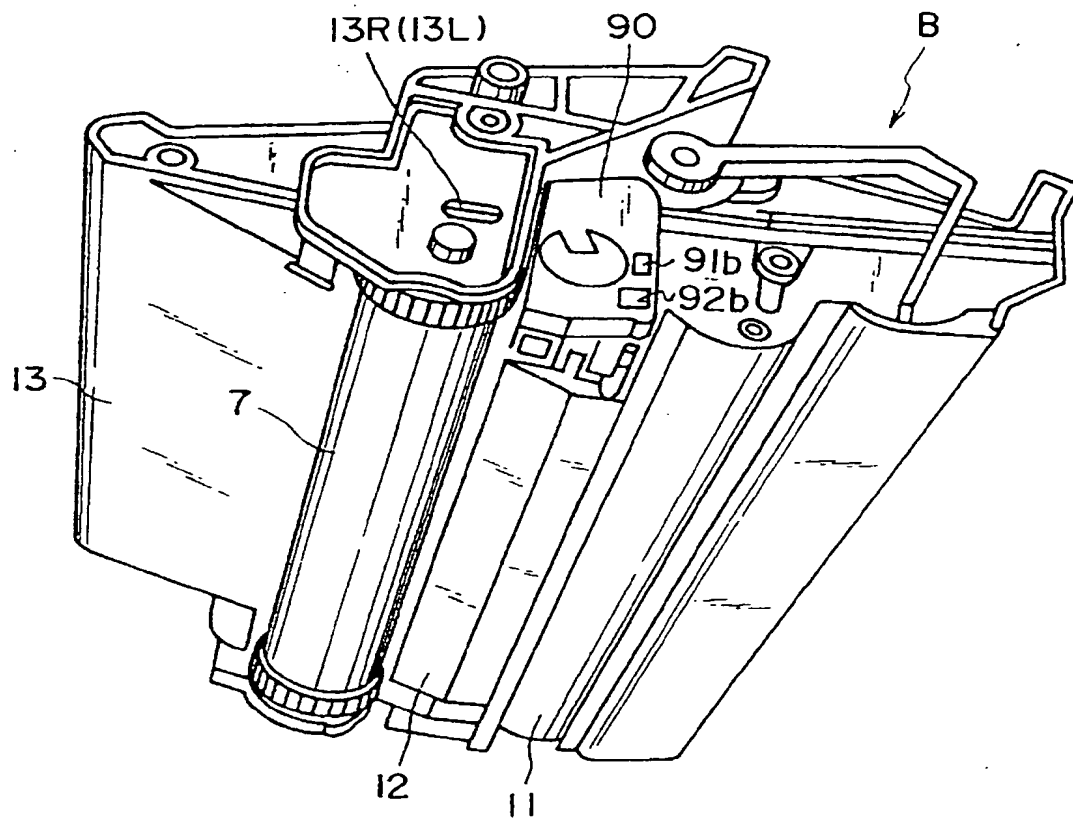


FIG. 4

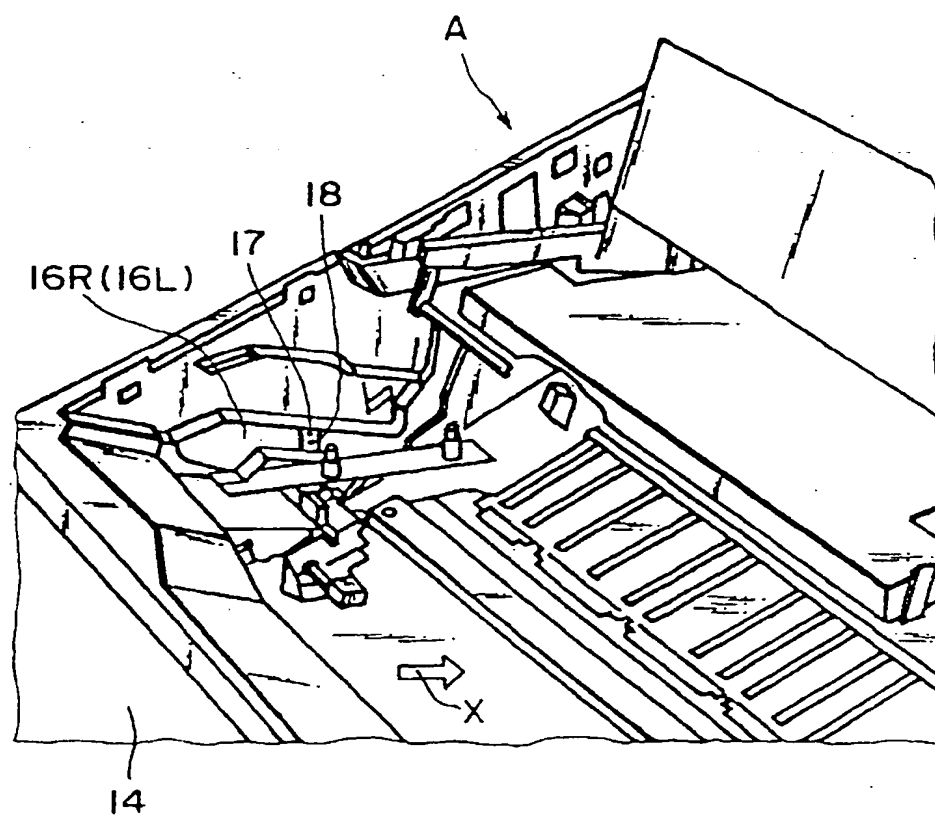


FIG. 5

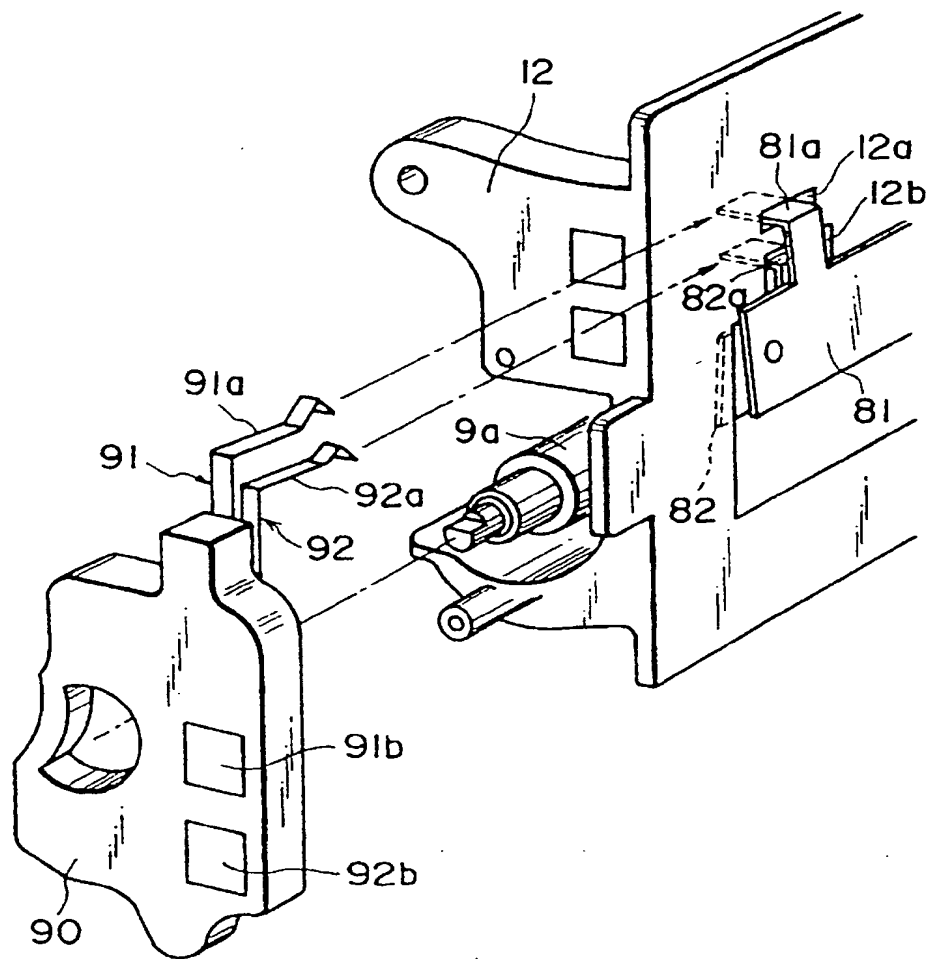


FIG. 6

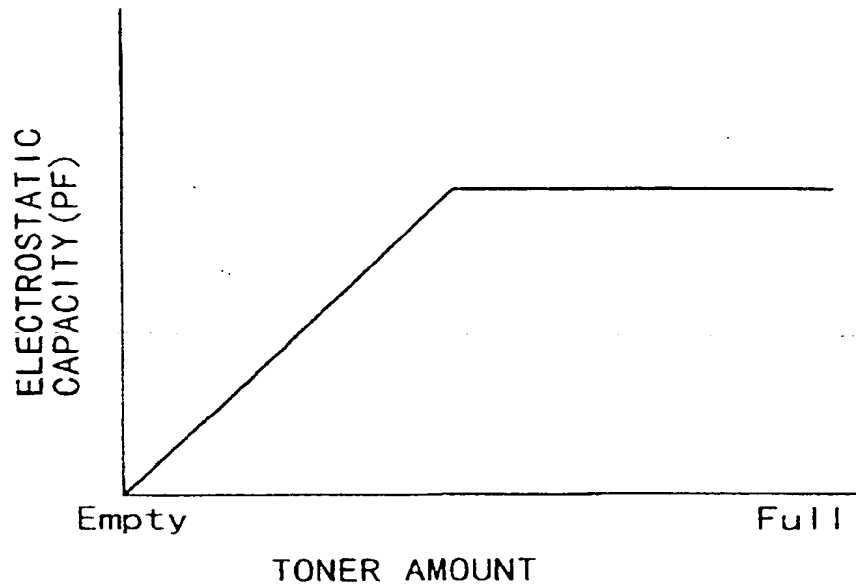


FIG. 7

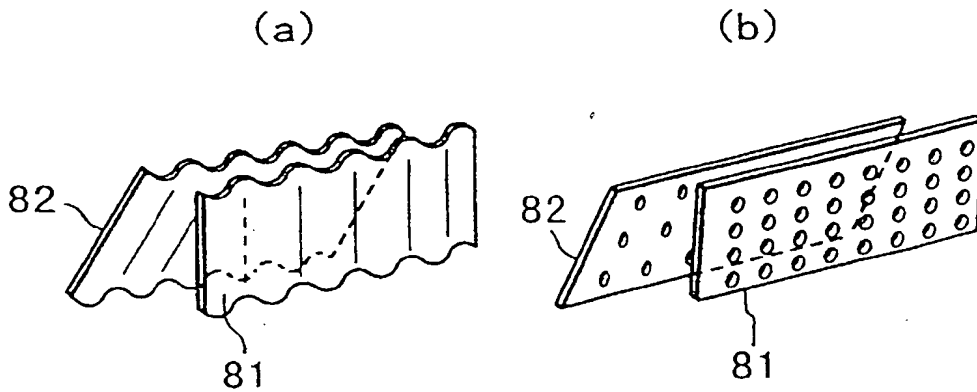


FIG. 8



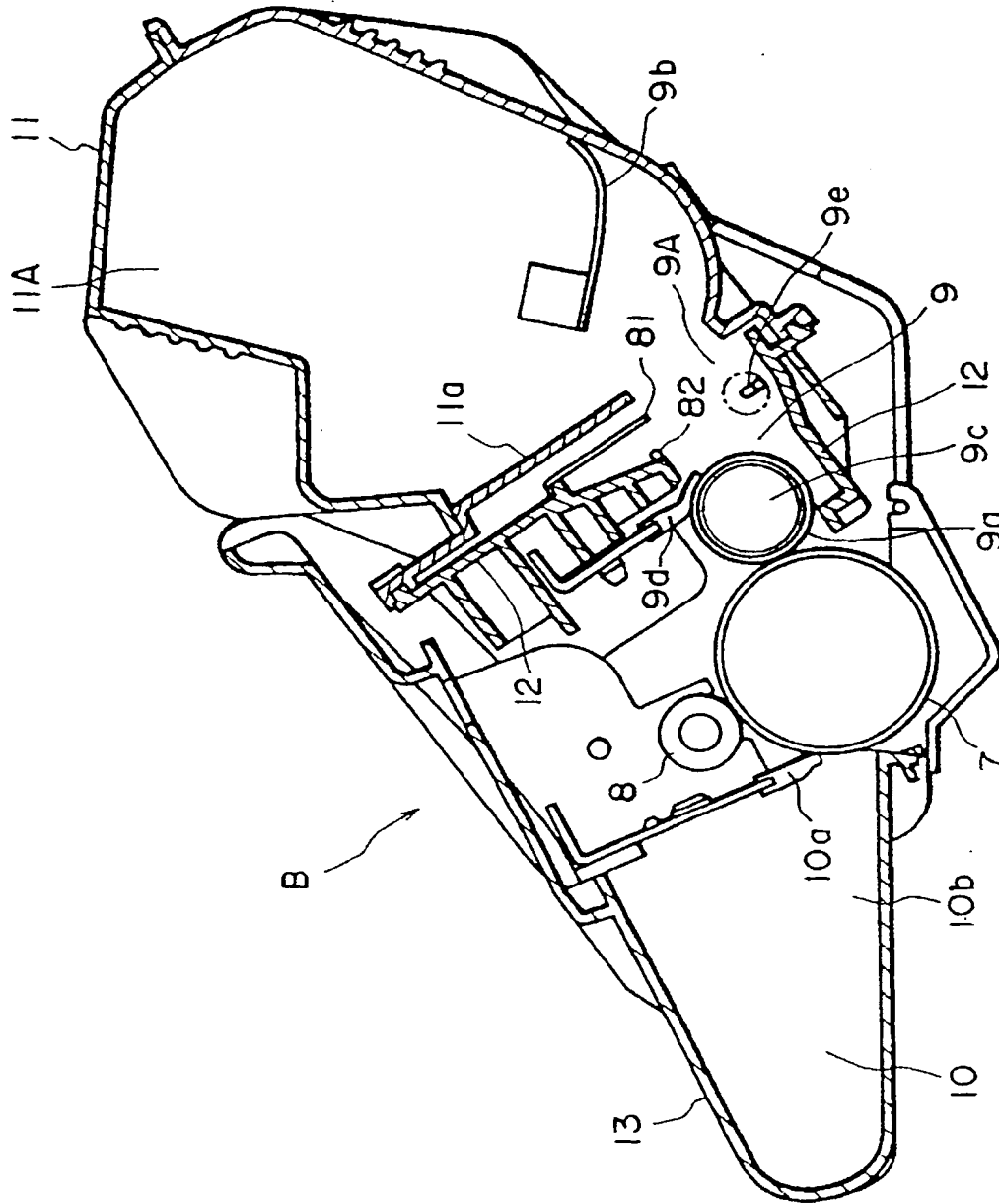


FIG. 9

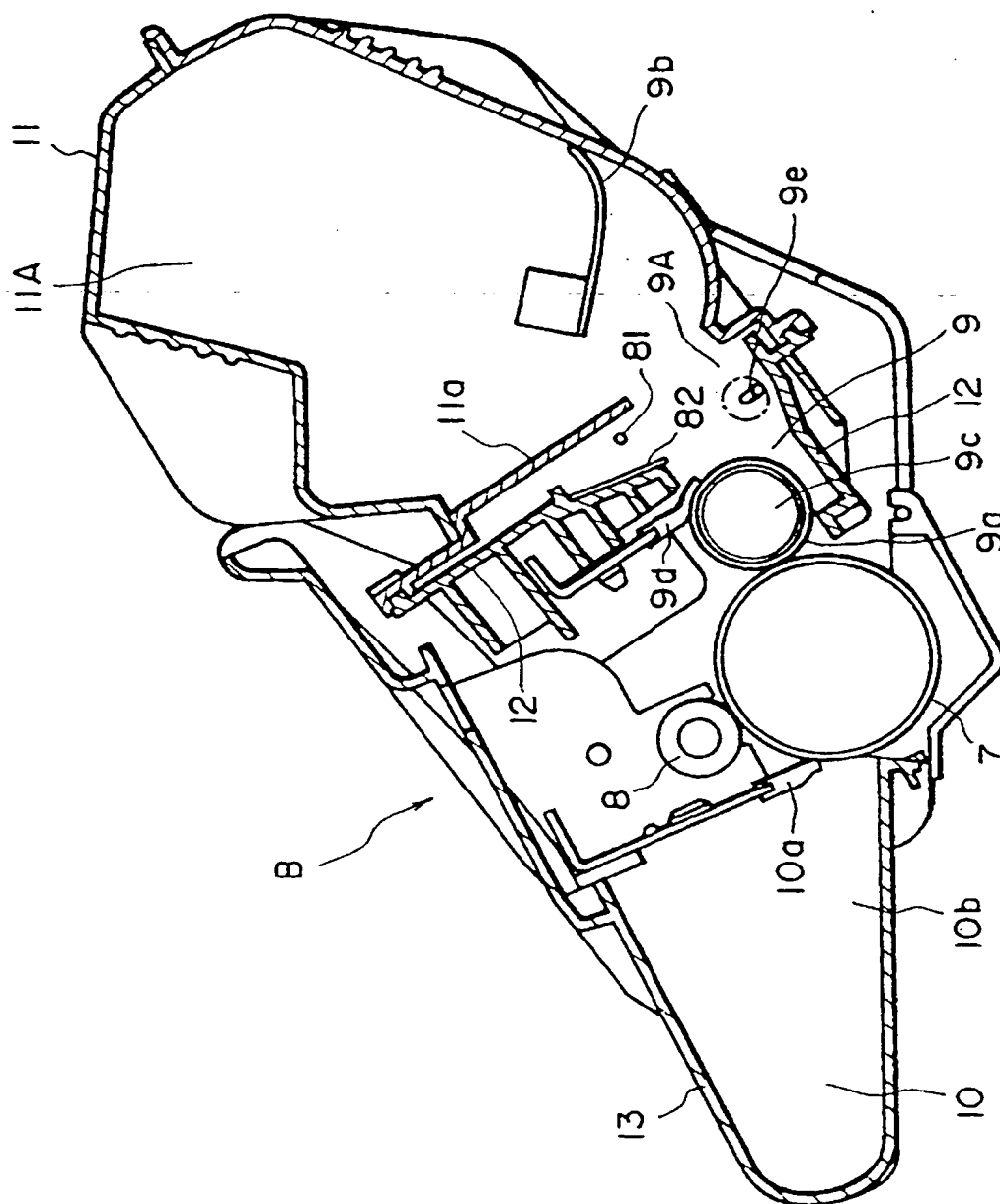
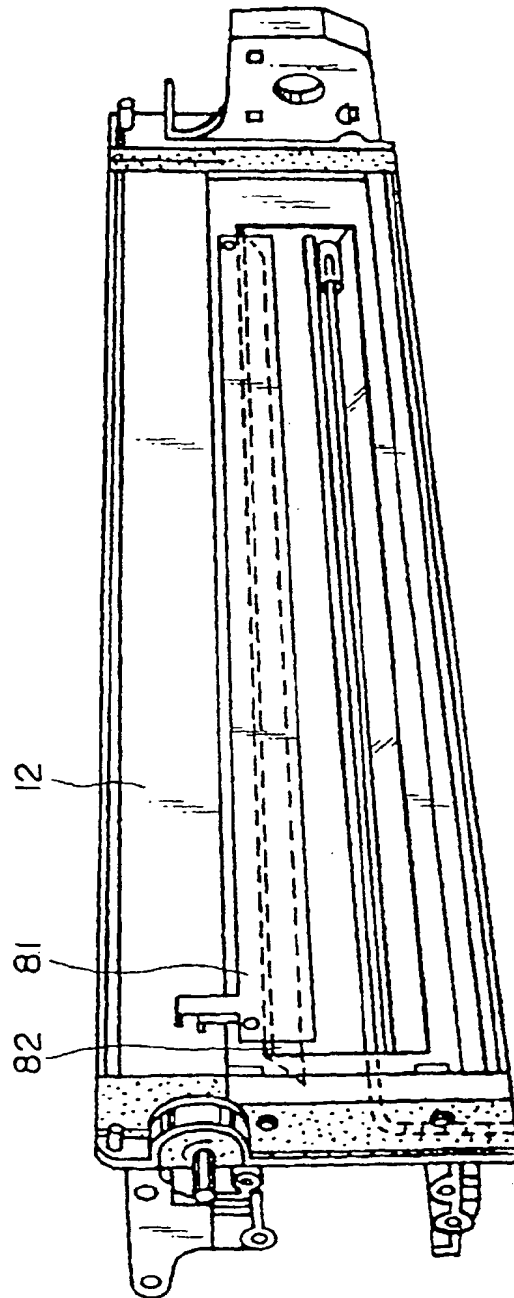


FIG. 10



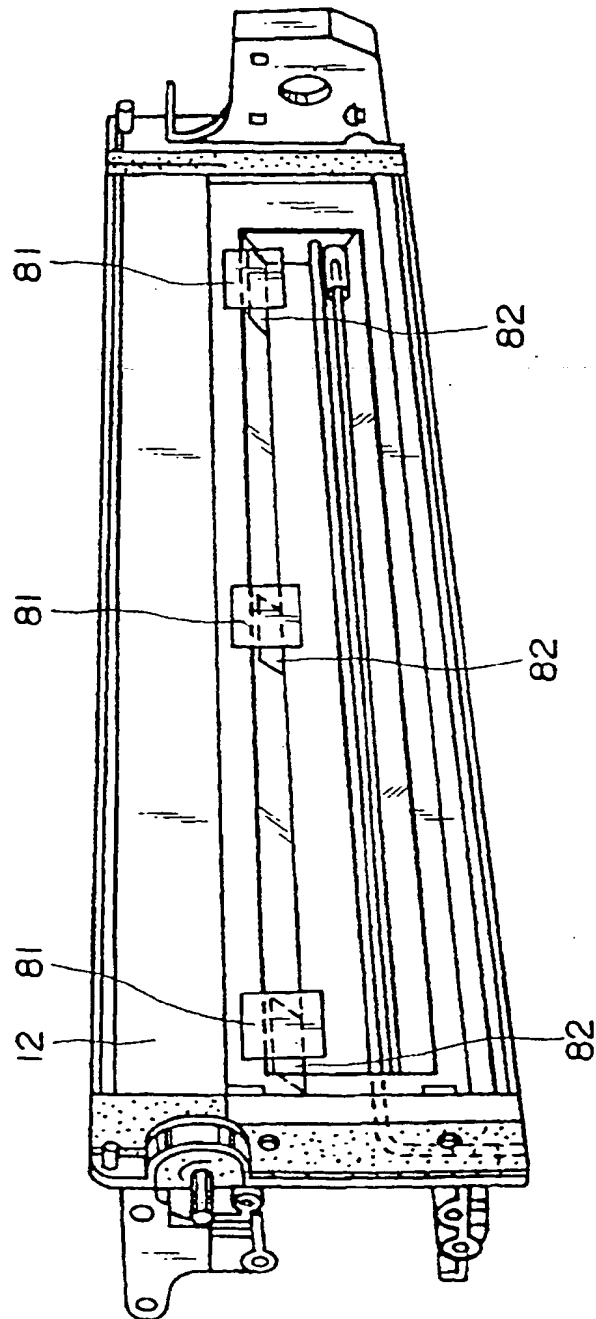


FIG. 12

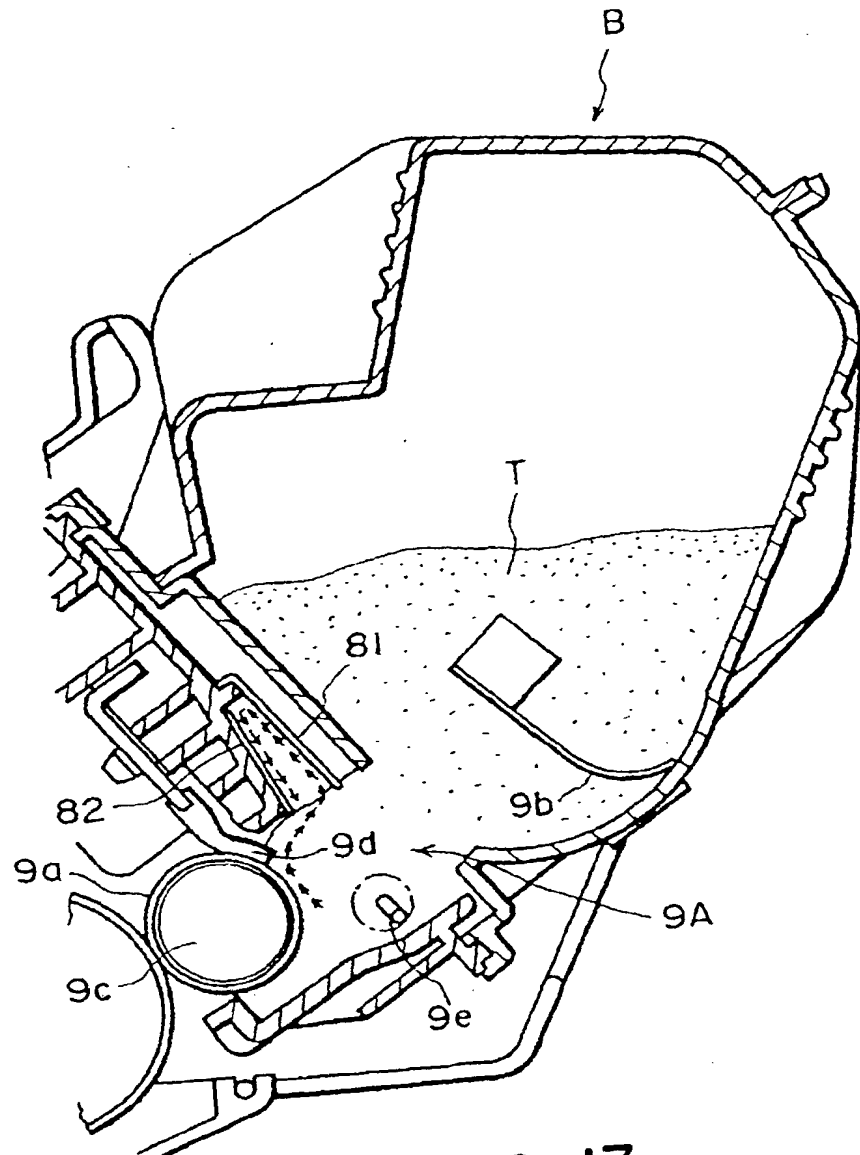


FIG. 13

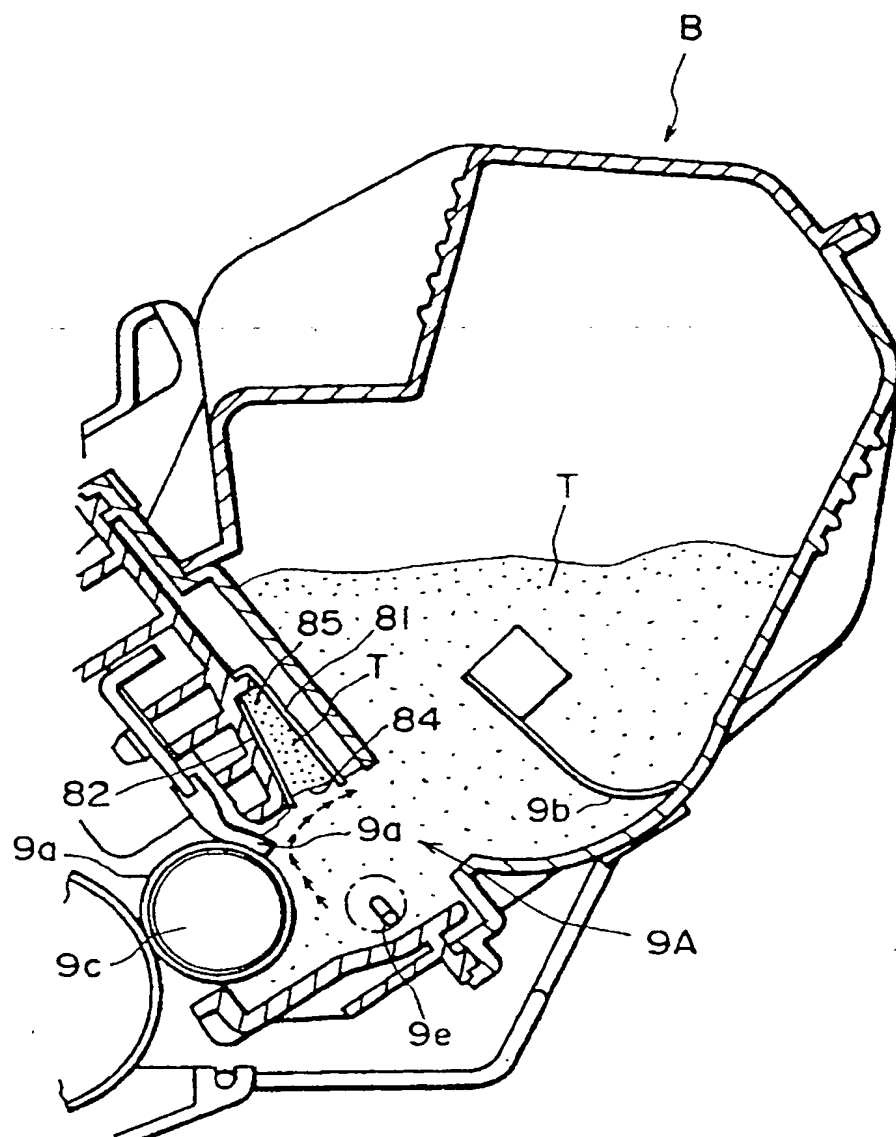


FIG. 14

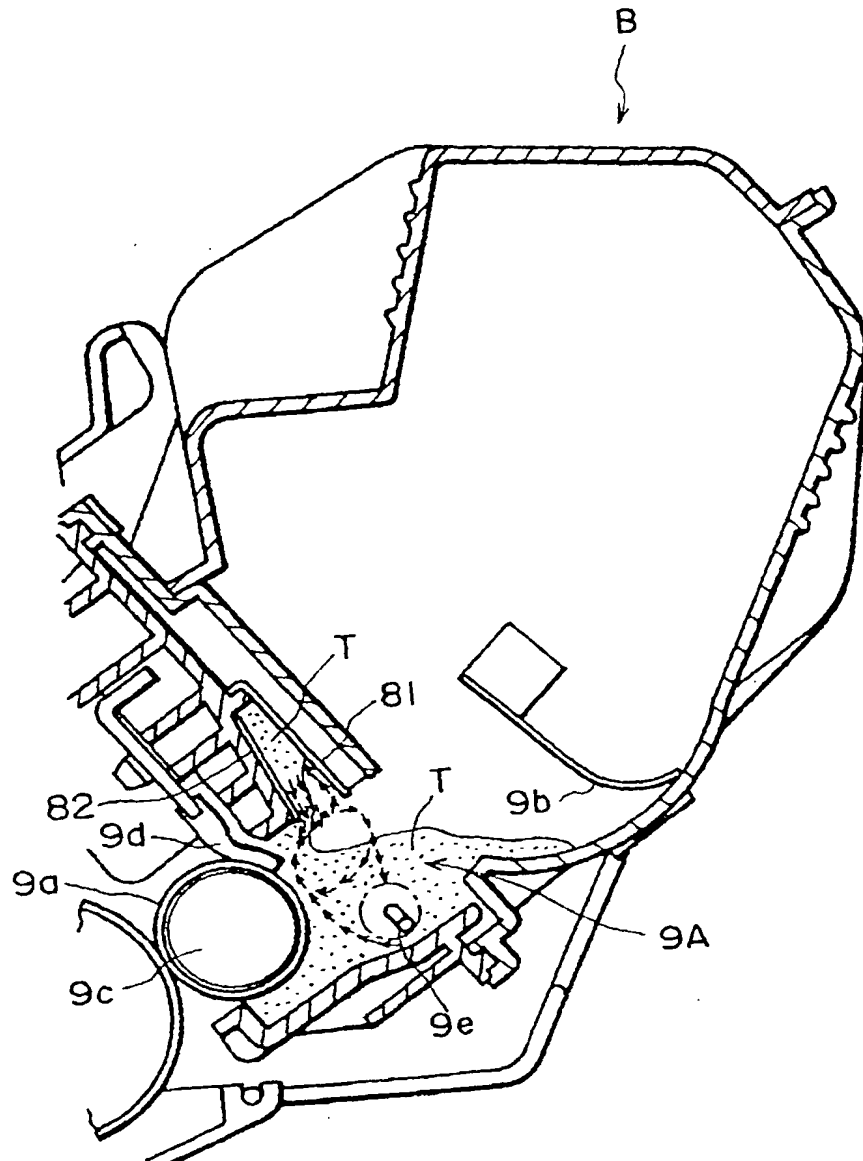


FIG. 15

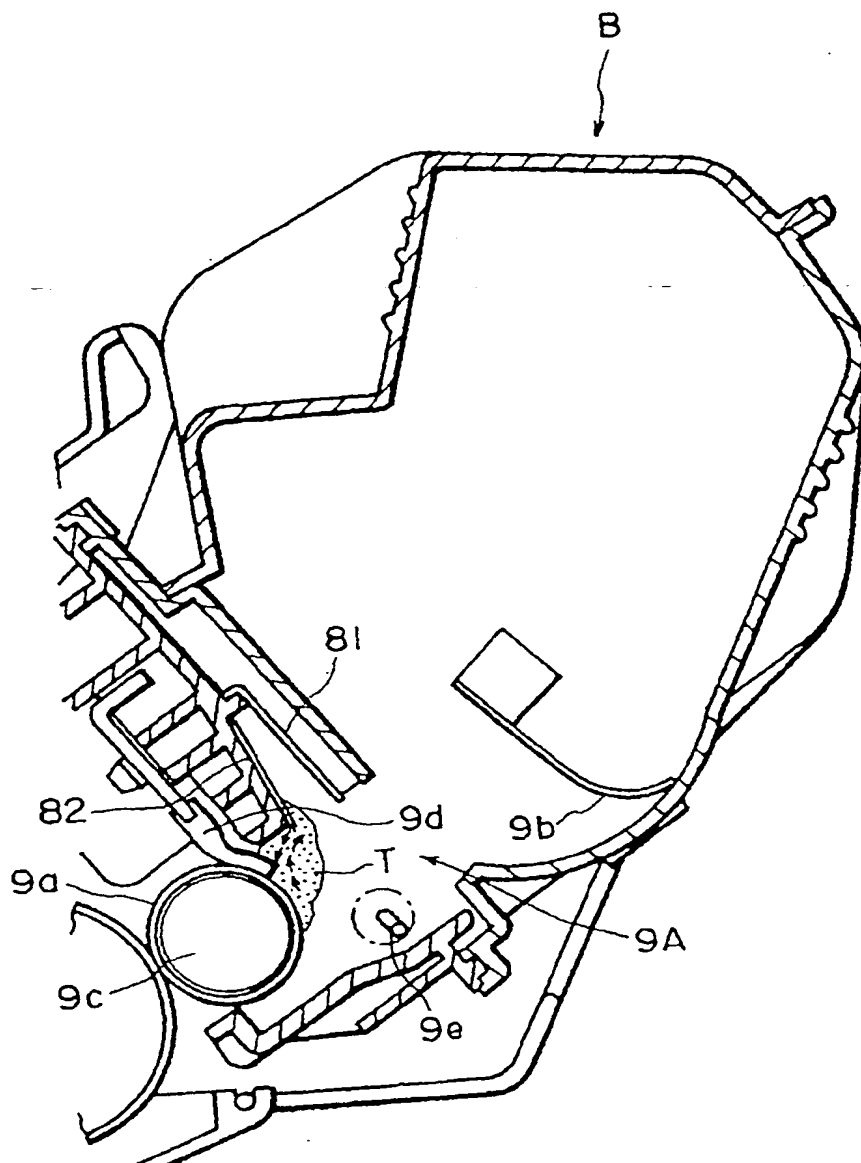


FIG. 16



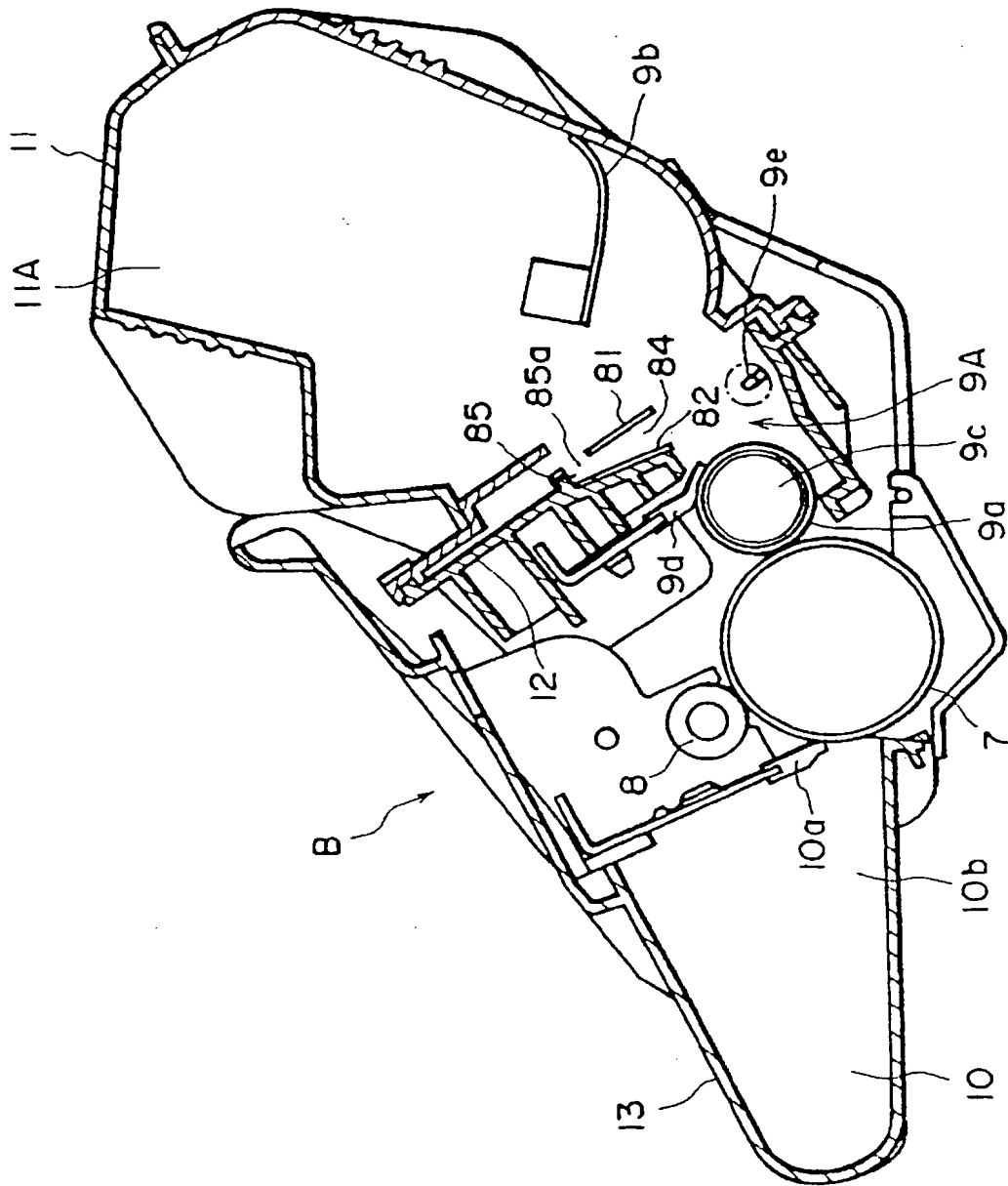


FIG. 17

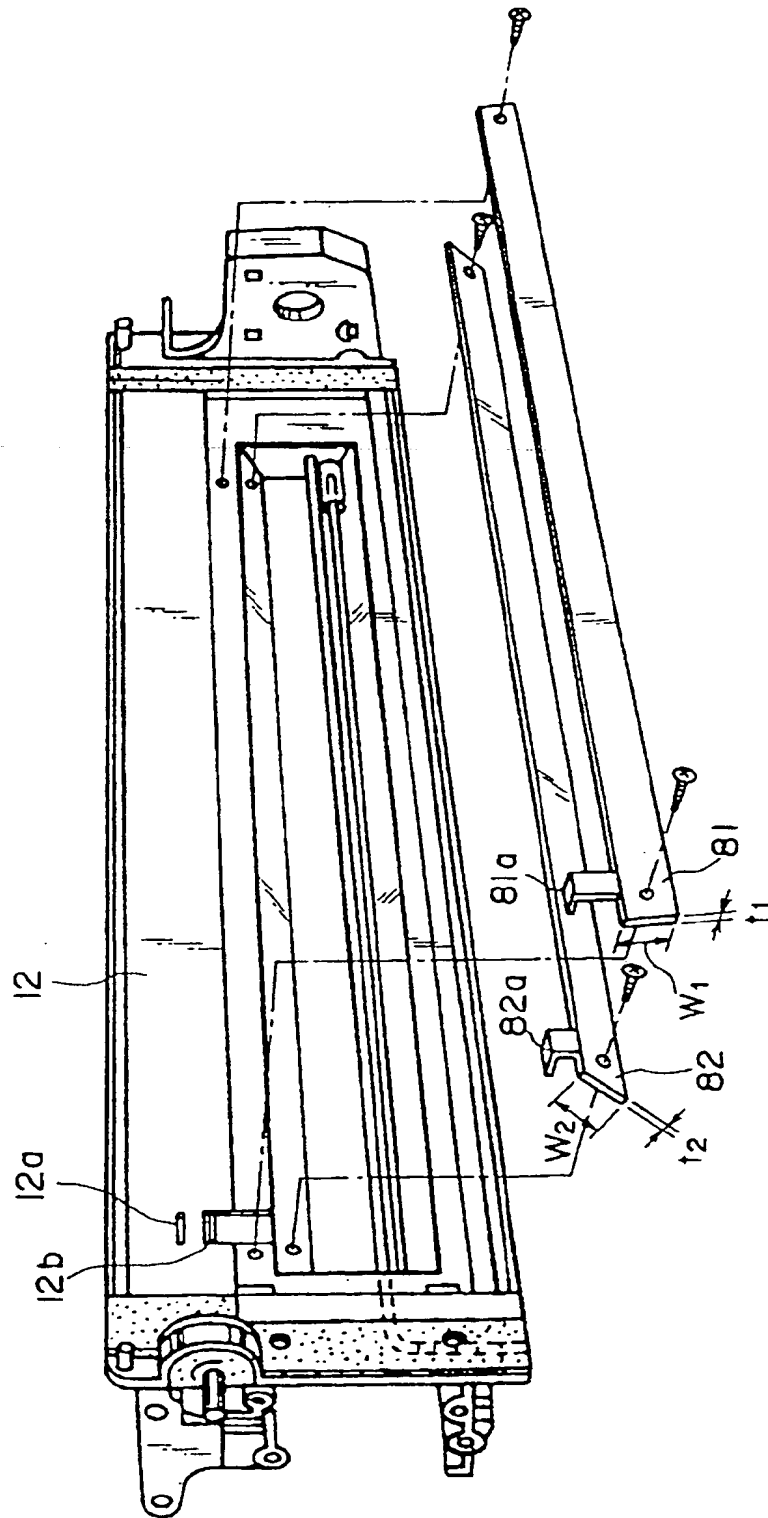
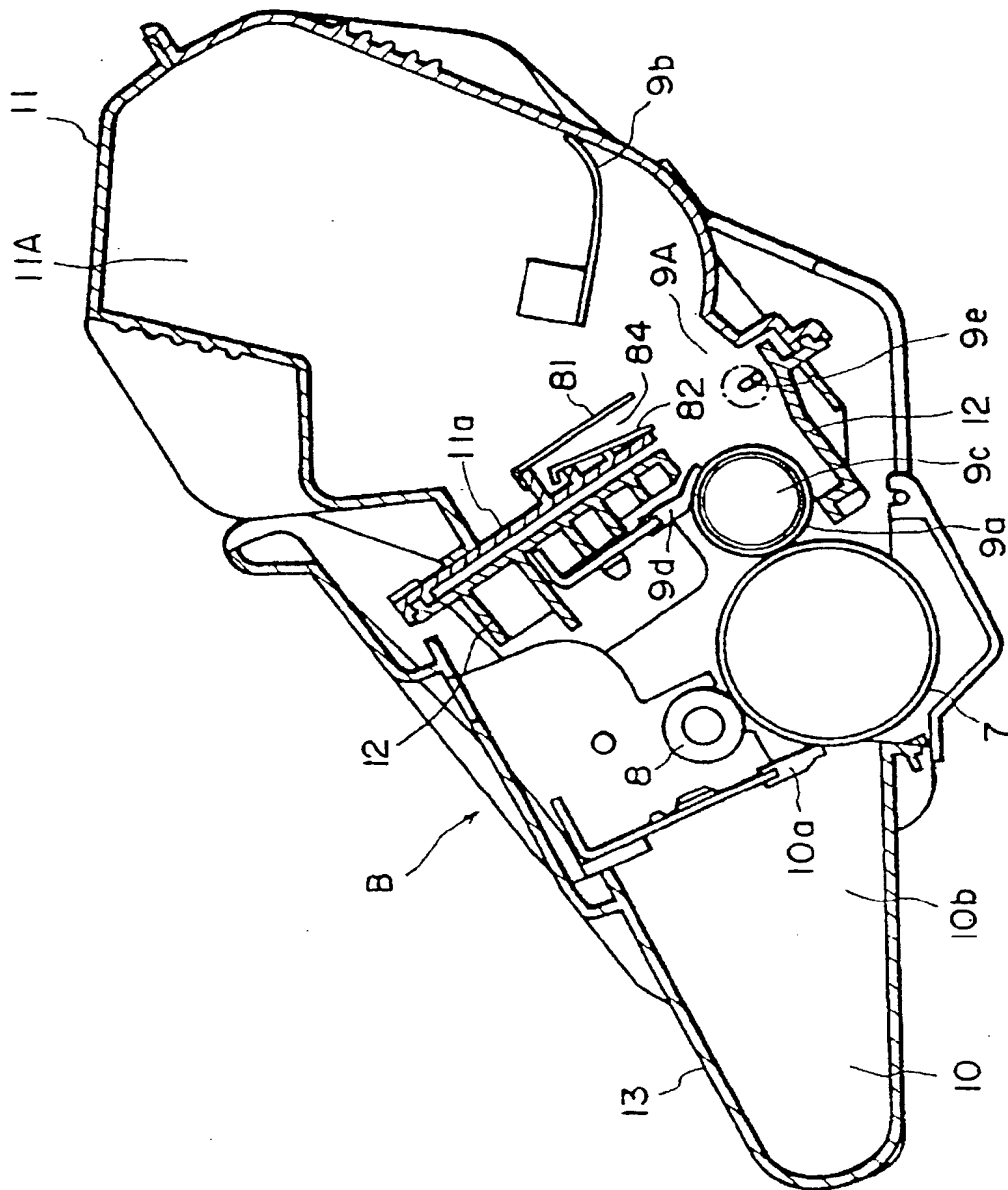


FIG. 18



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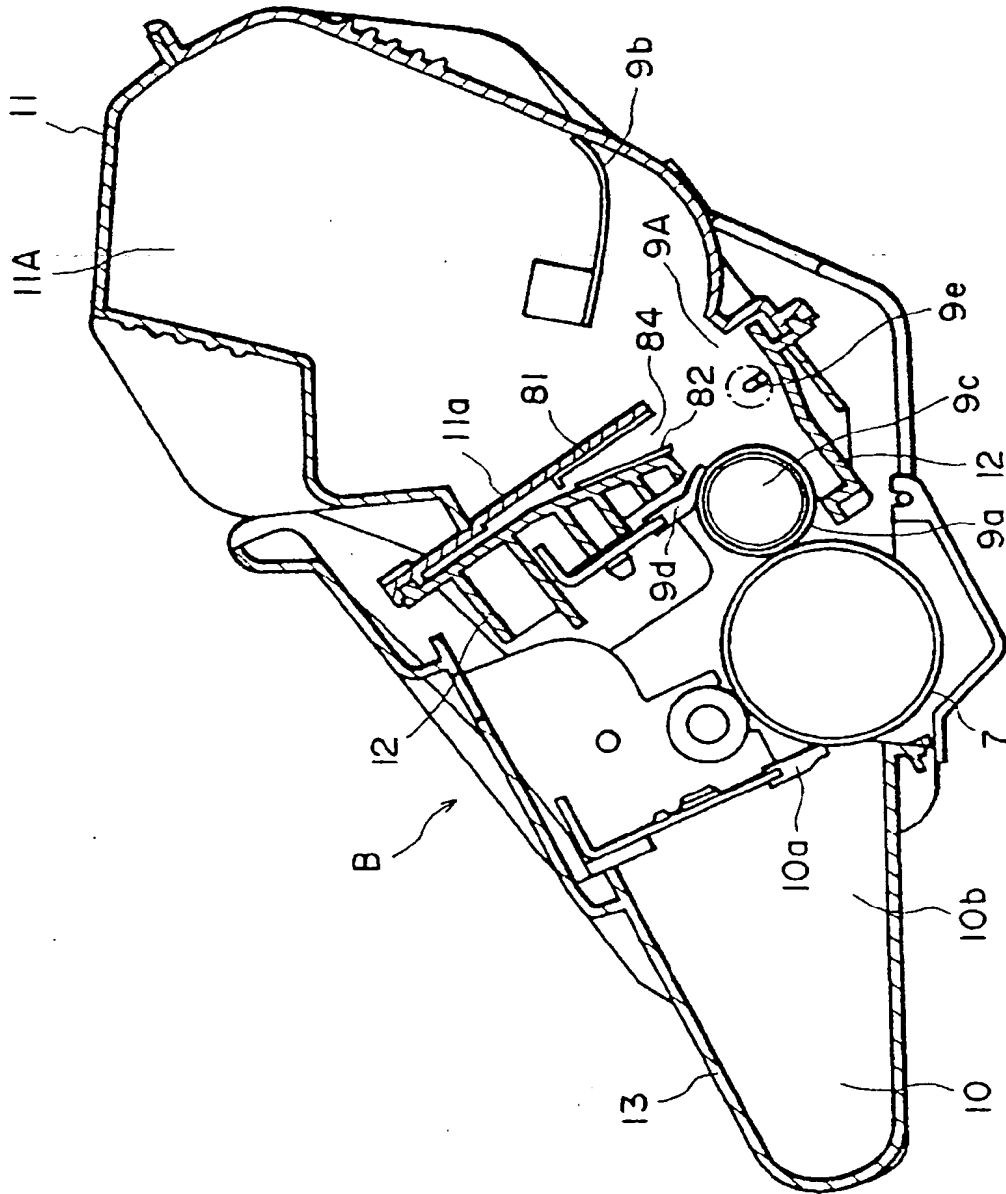


FIG. 20

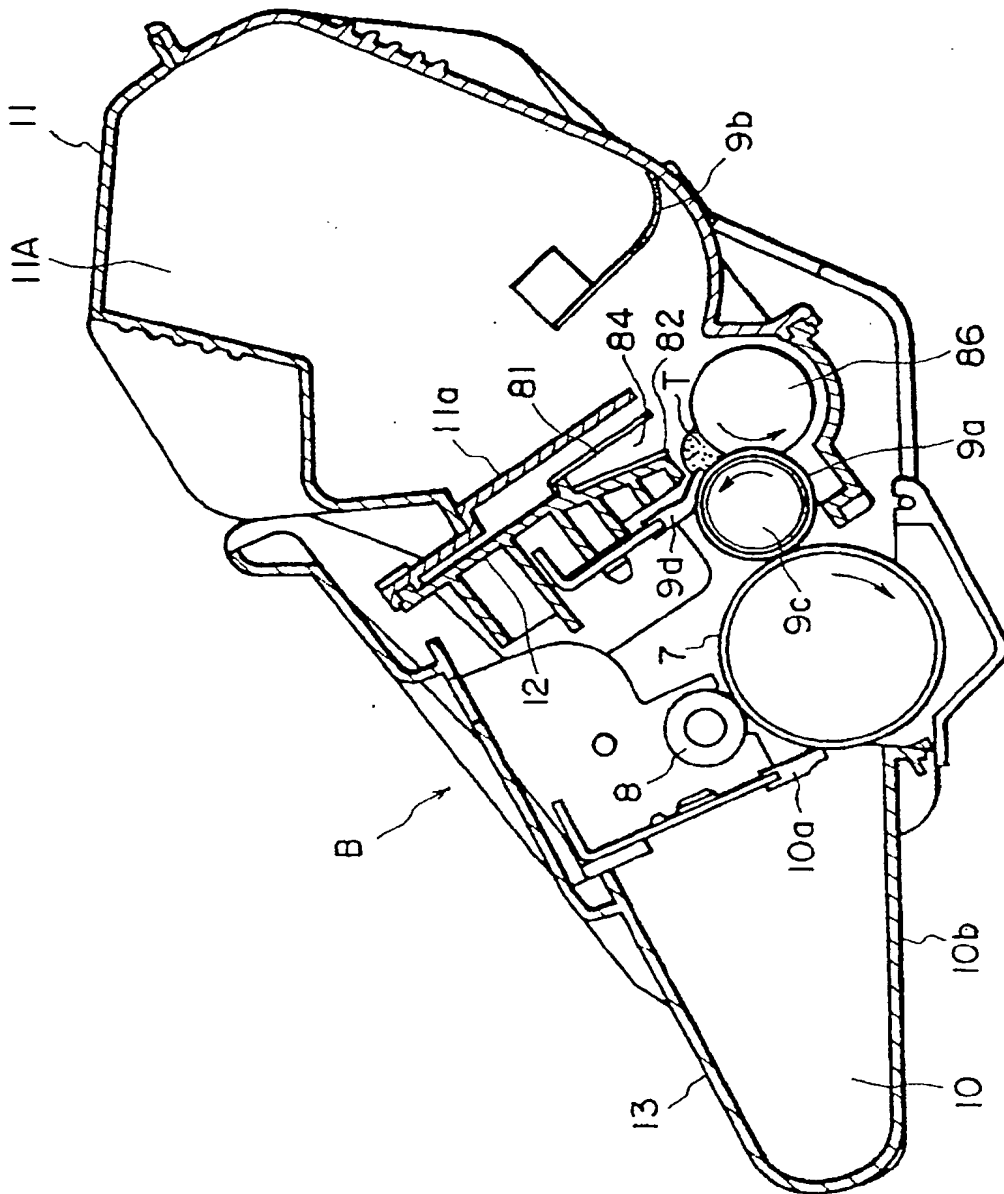


FIG. 21

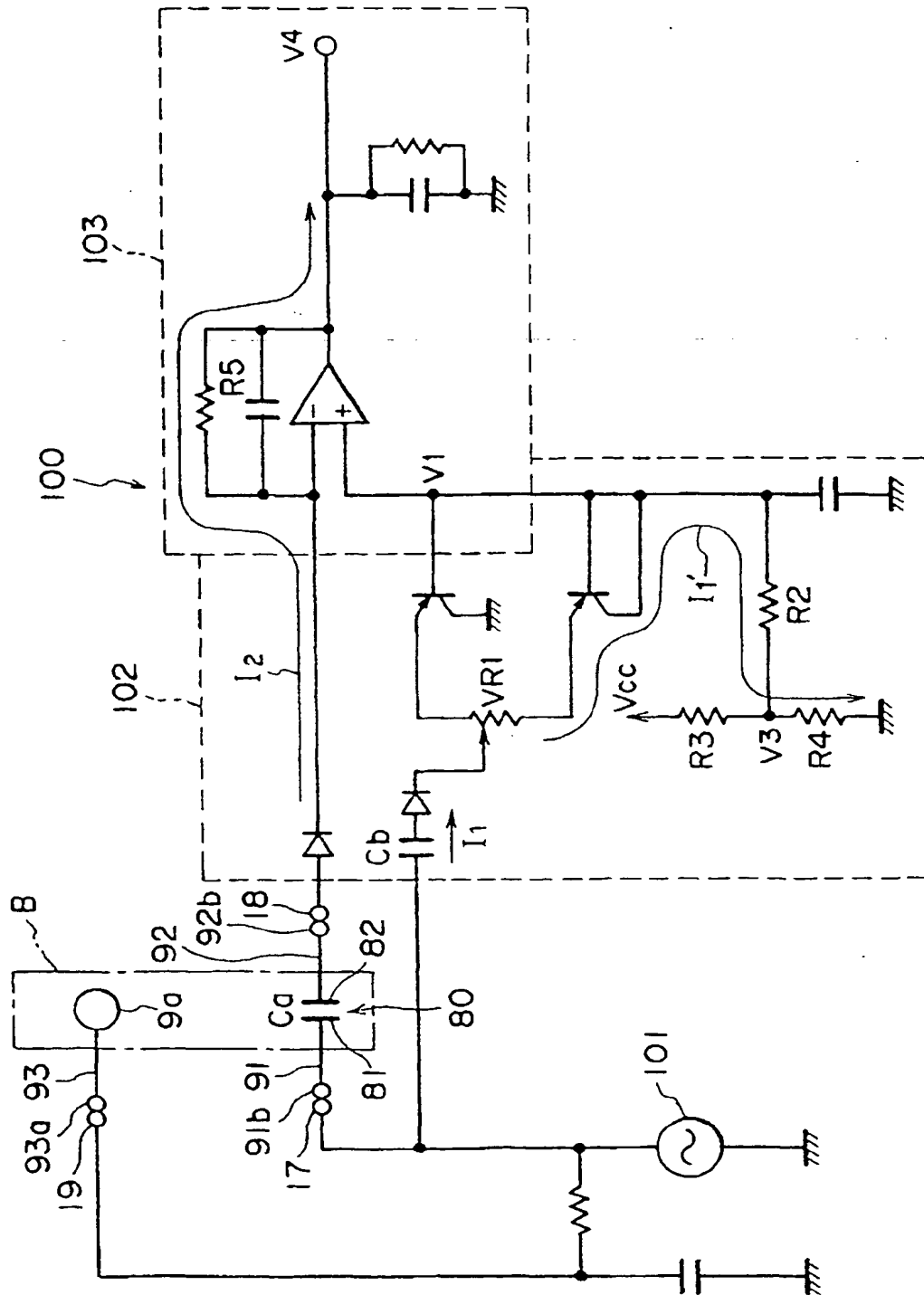


FIG. 22

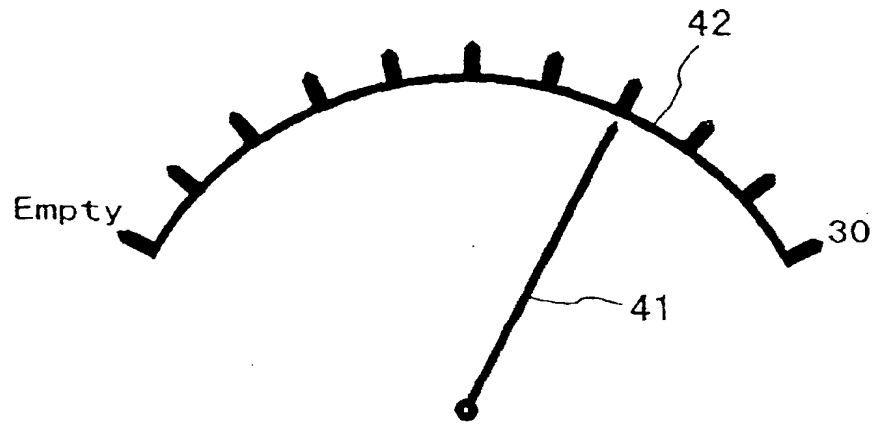


FIG. 23

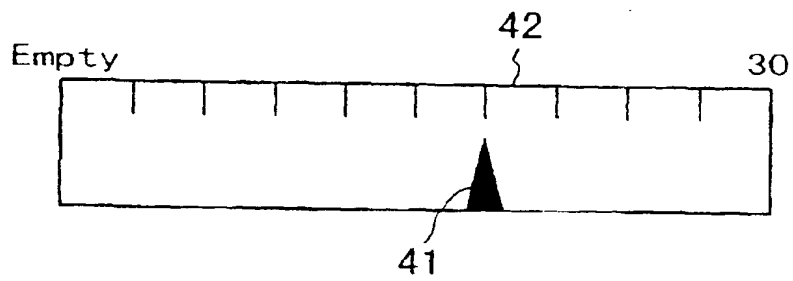


FIG. 24

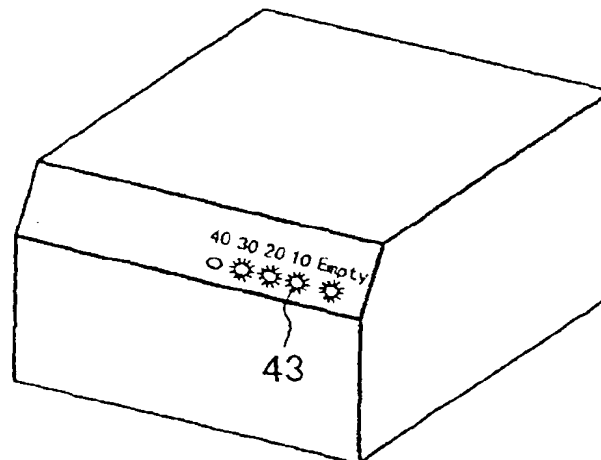


FIG. 25

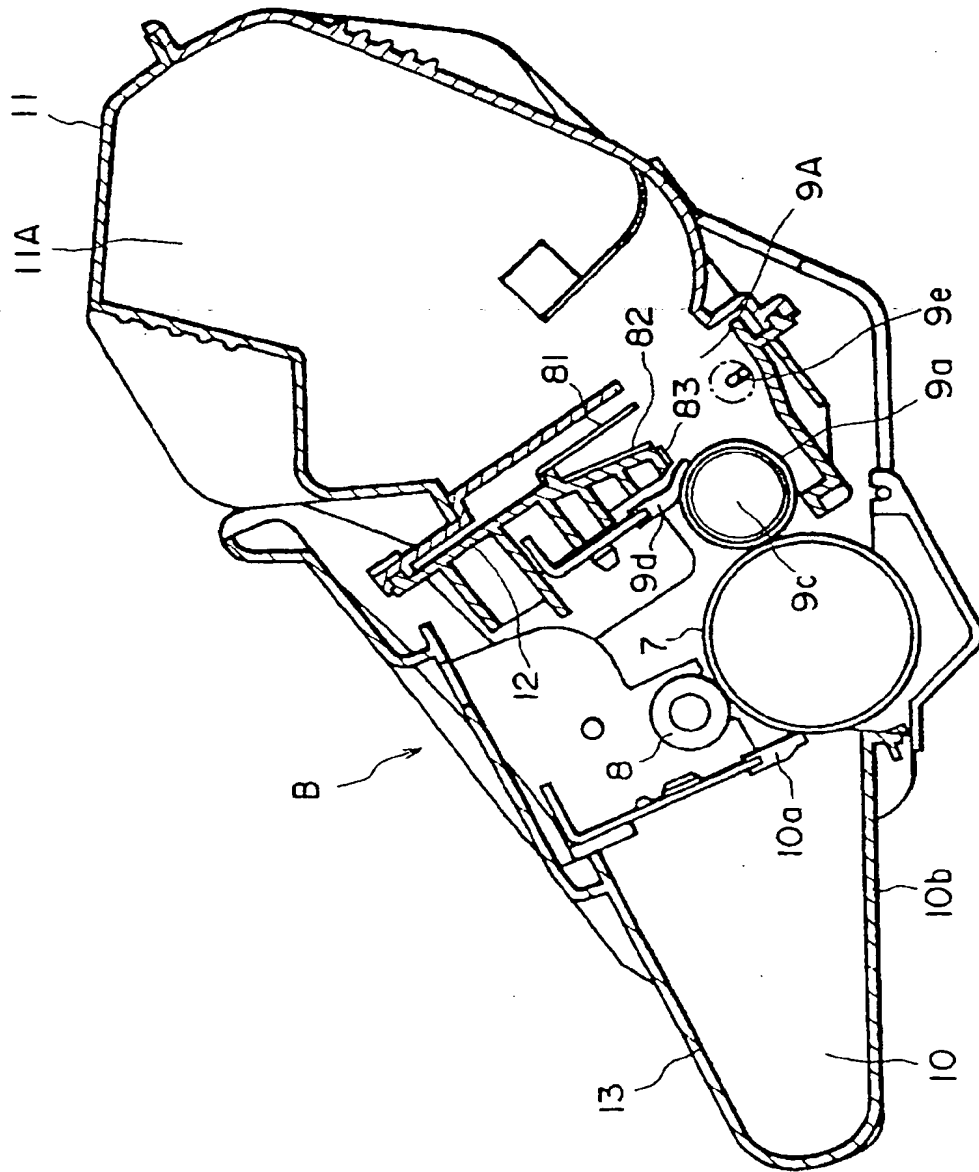


FIG. 26



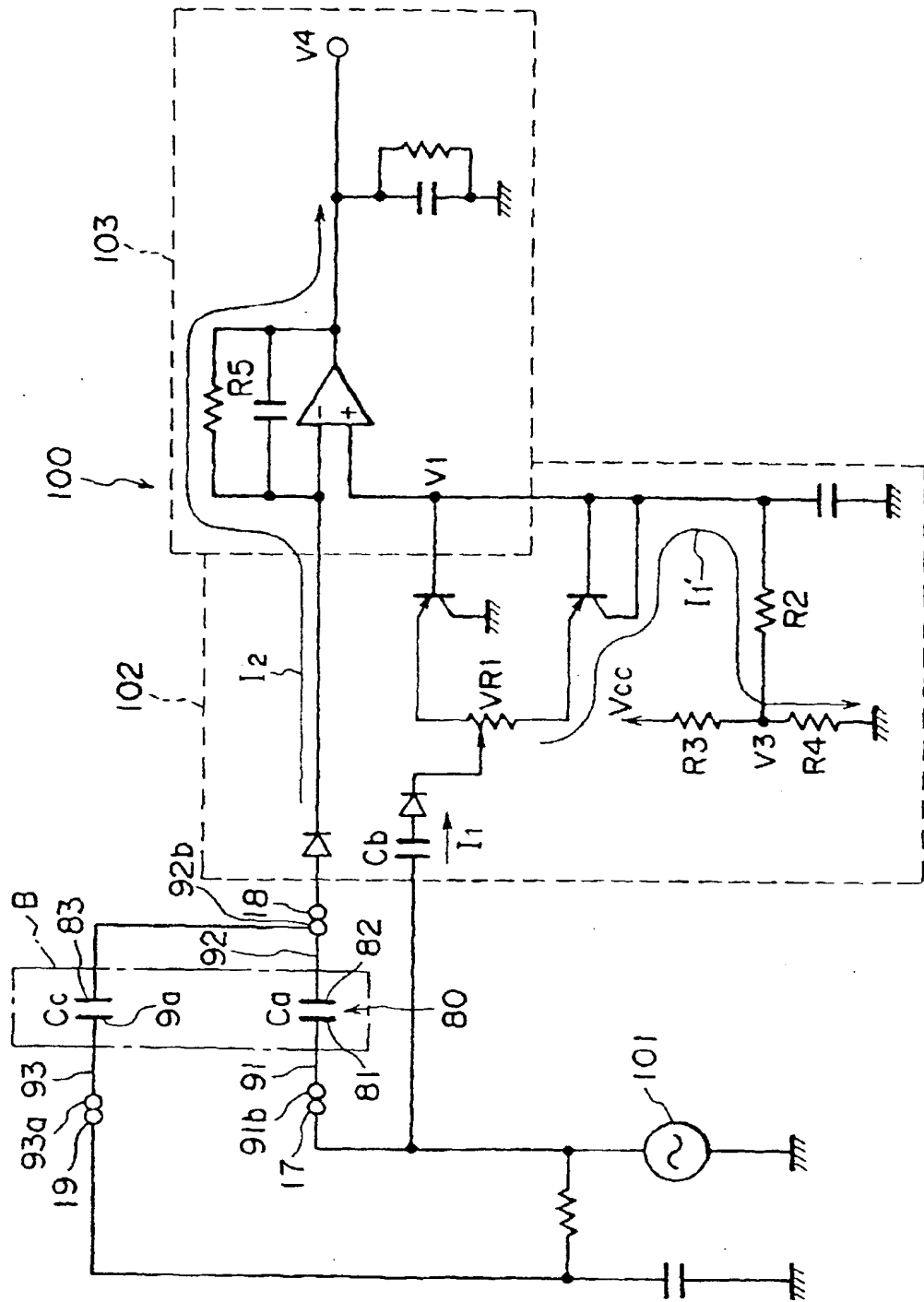


FIG. 27

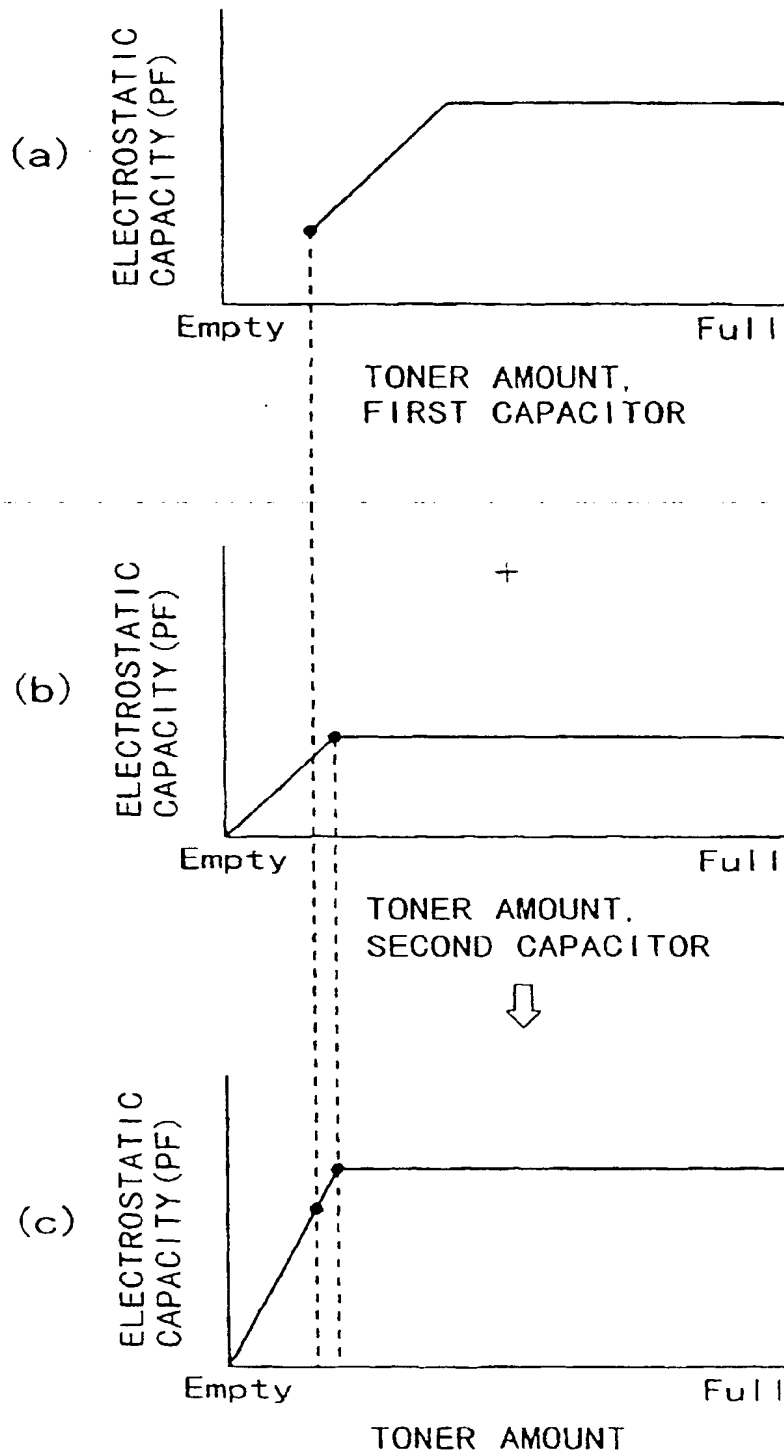


FIG. 28

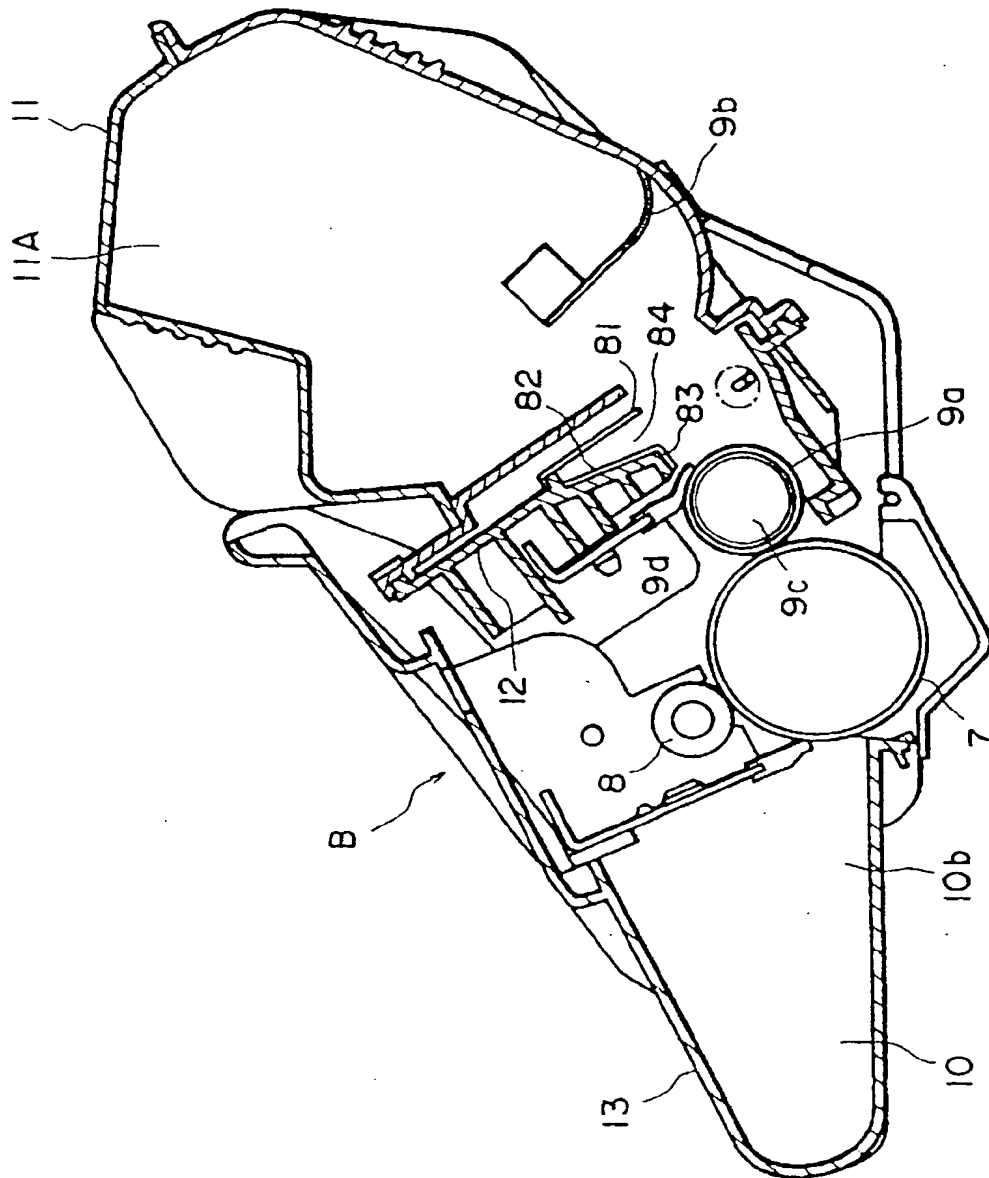


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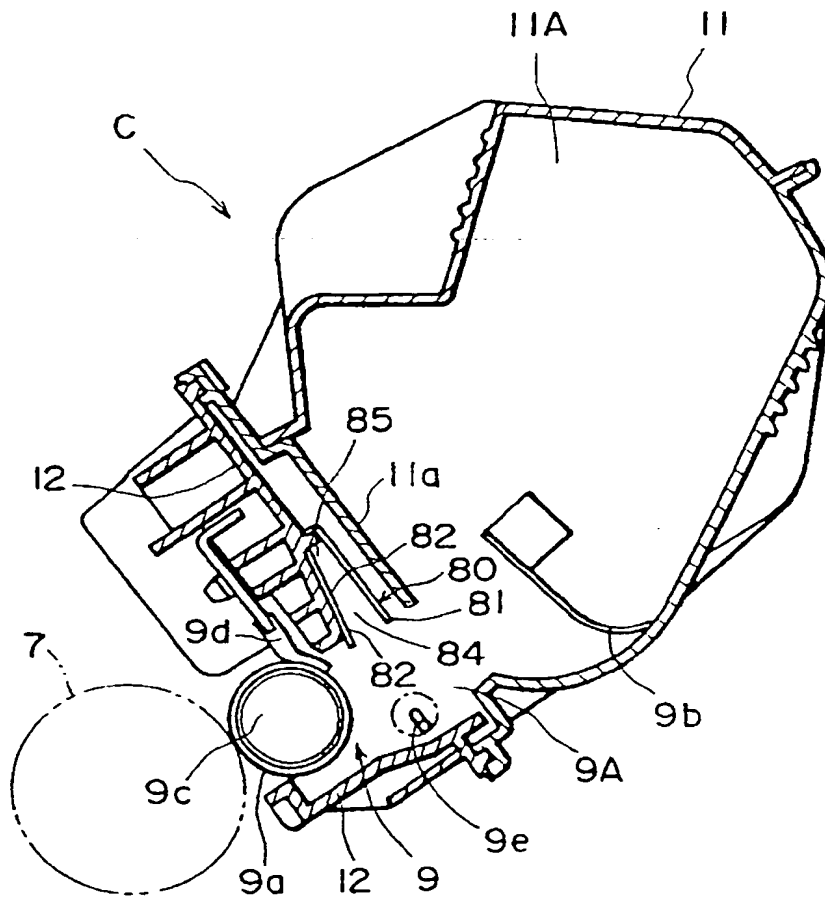


FIG. 30

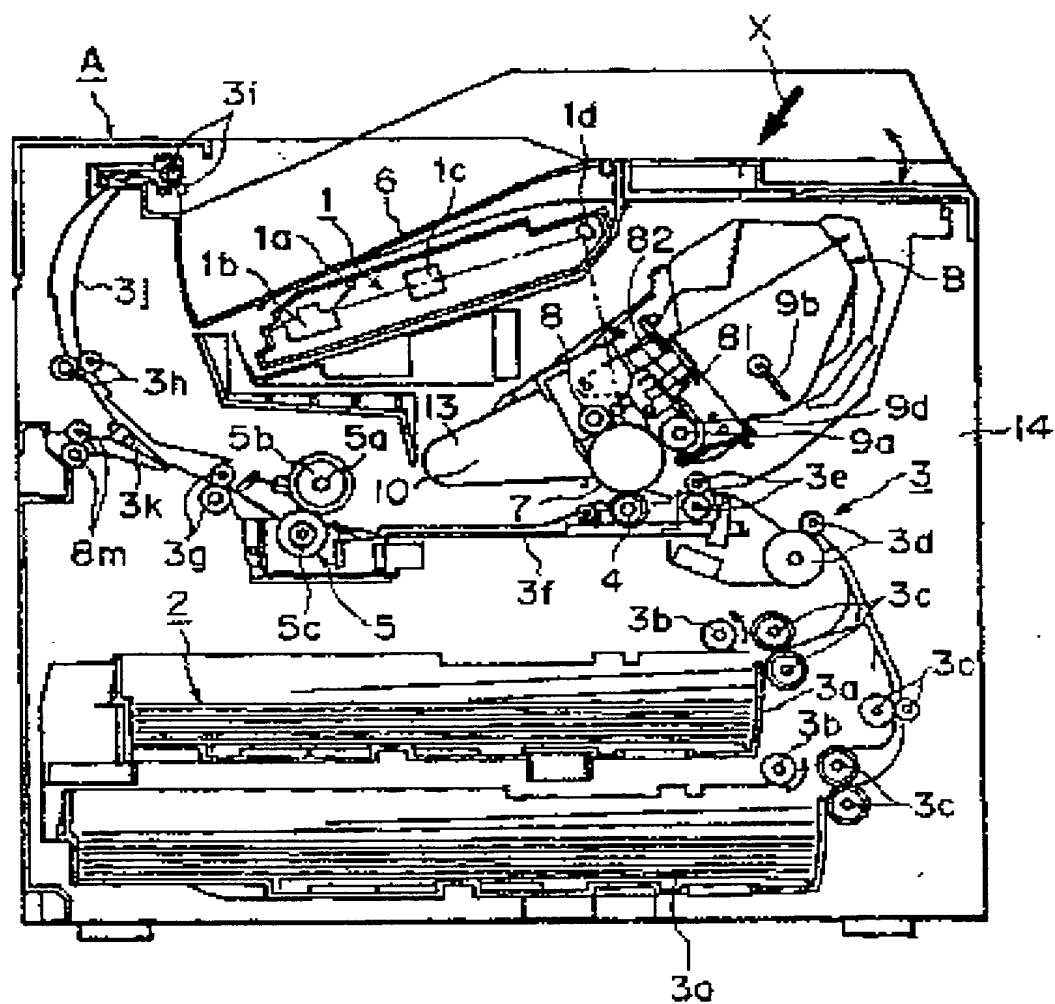


FIG. 1

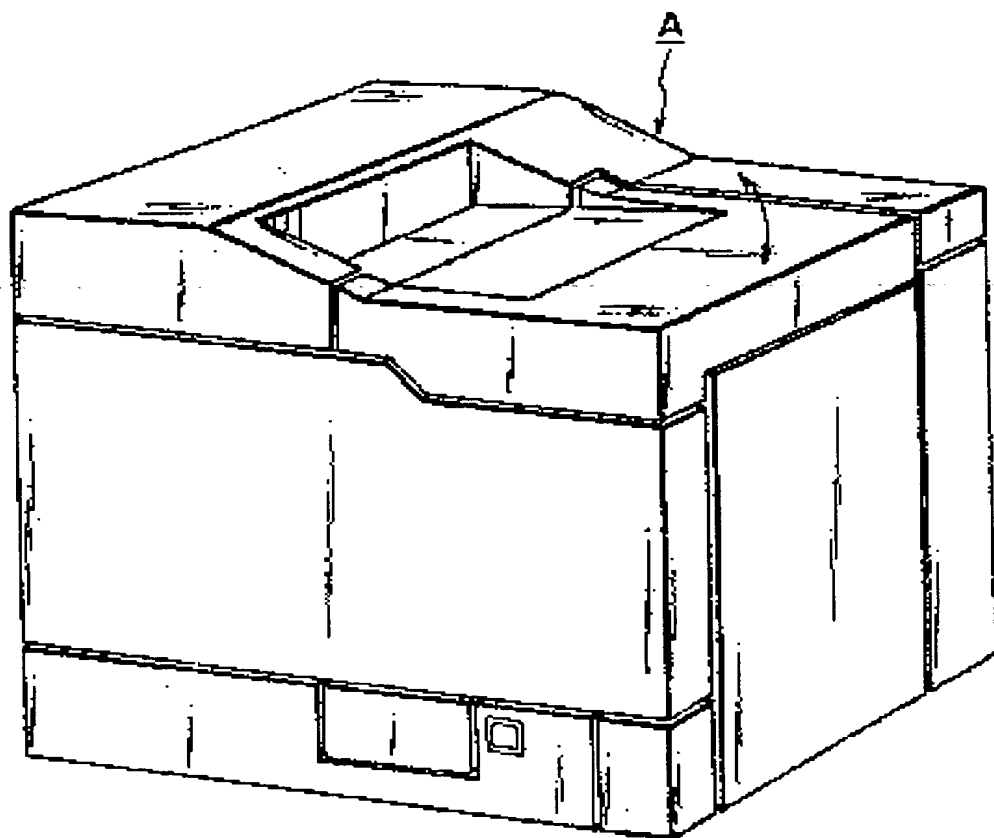


FIG. 2

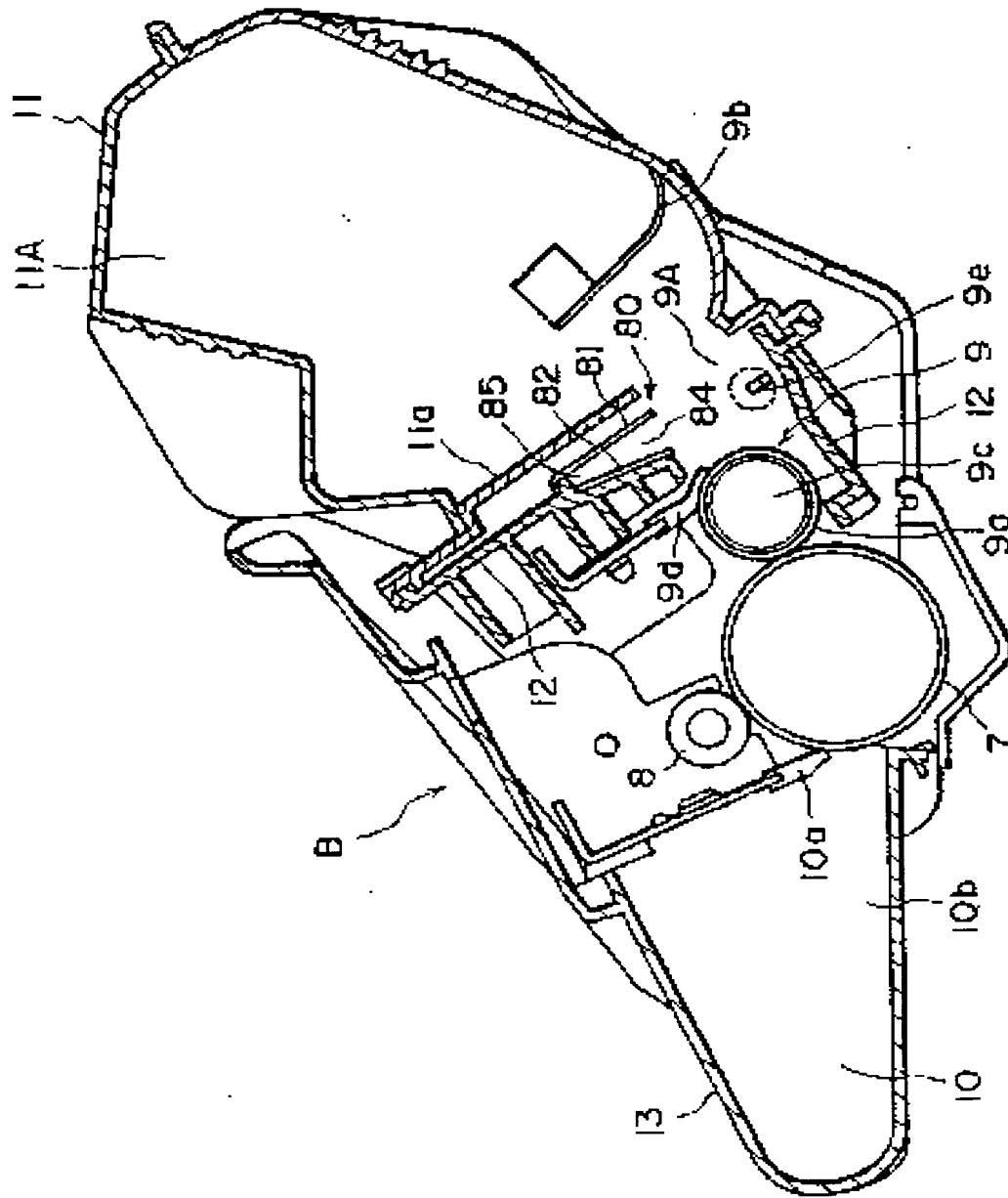


FIG. 3

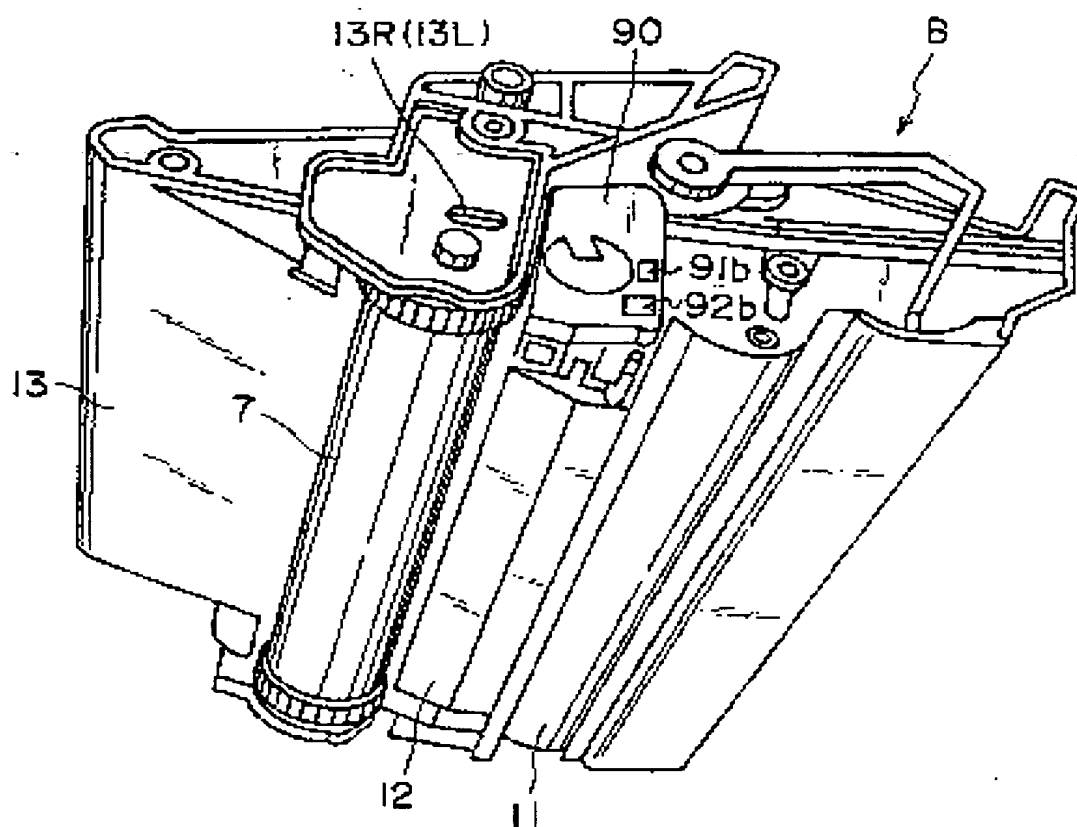


FIG. 4



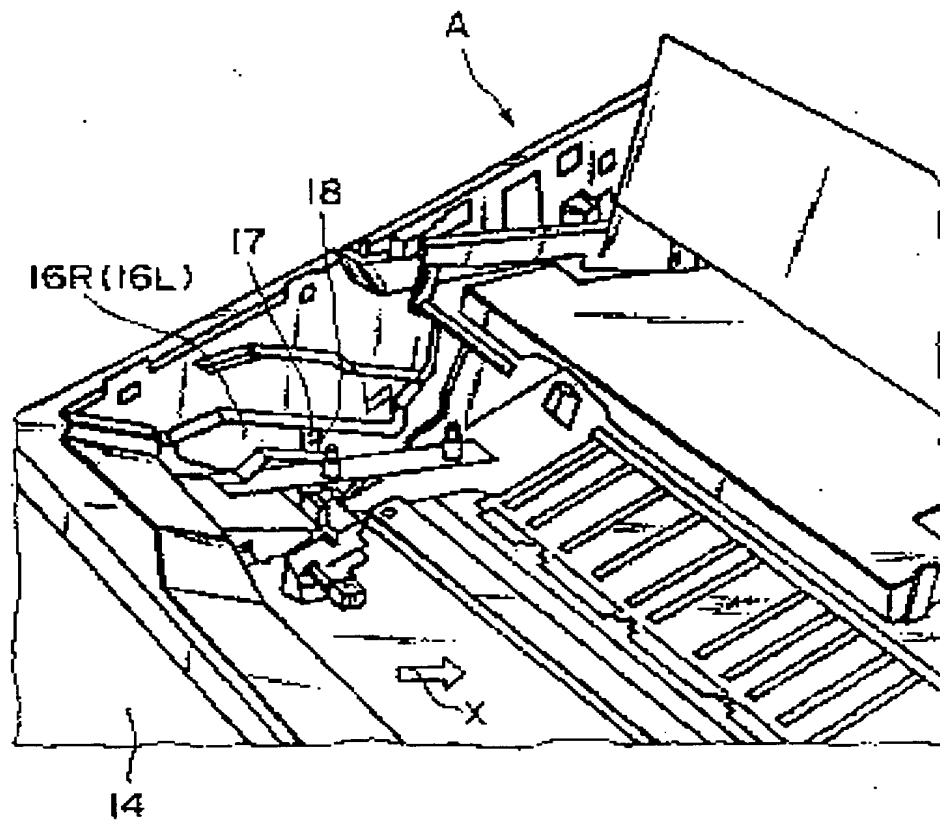


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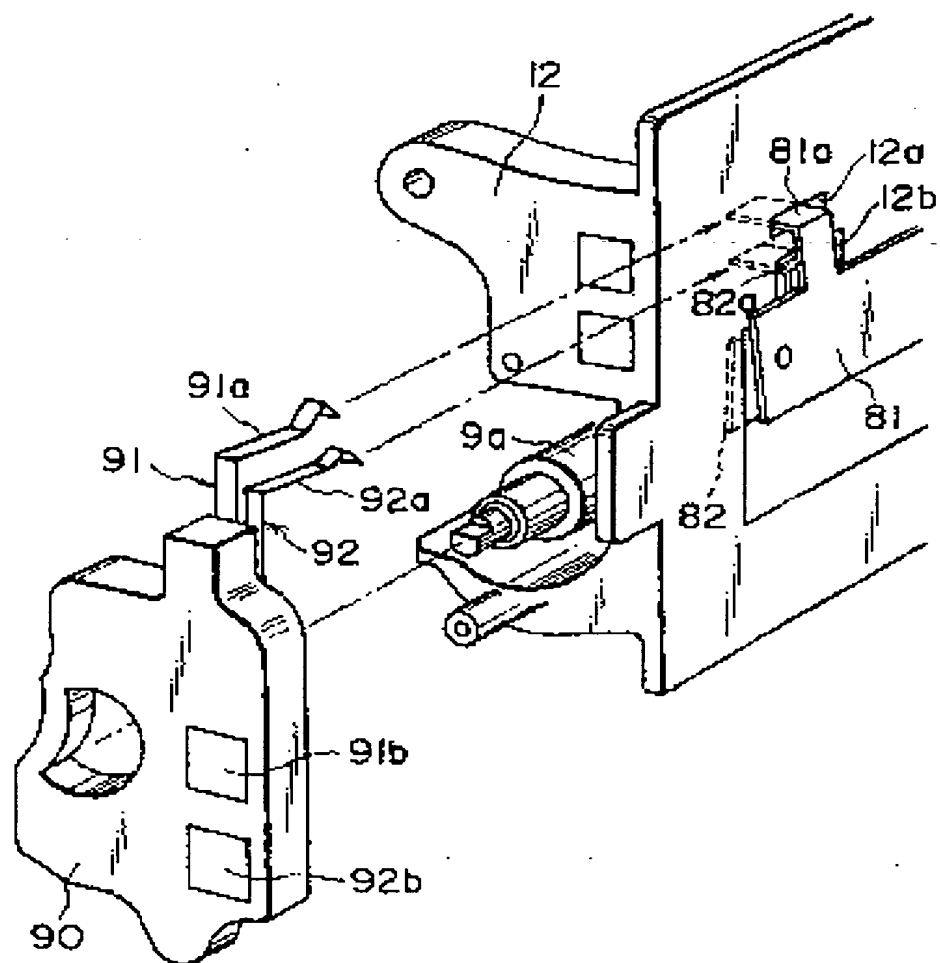


FIG. 6

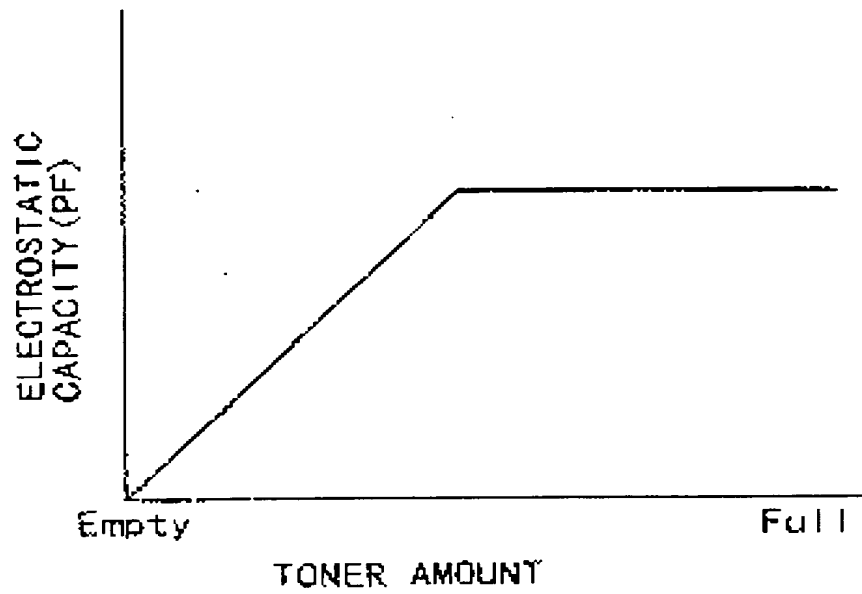


FIG. 7

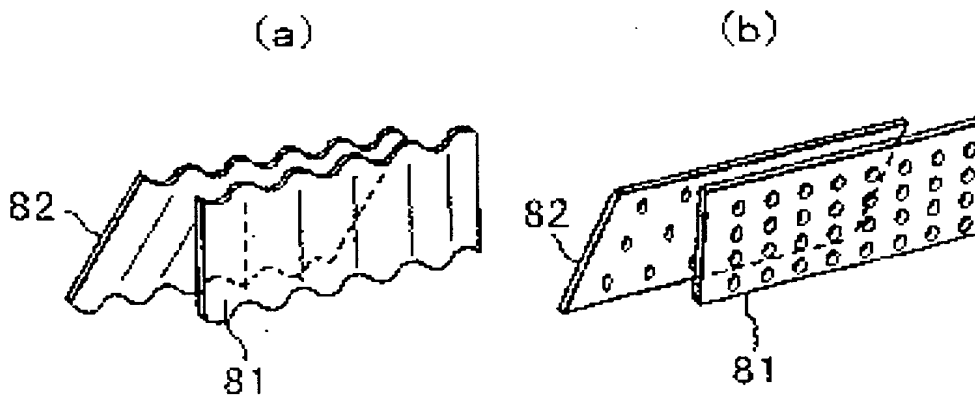


FIG. 8

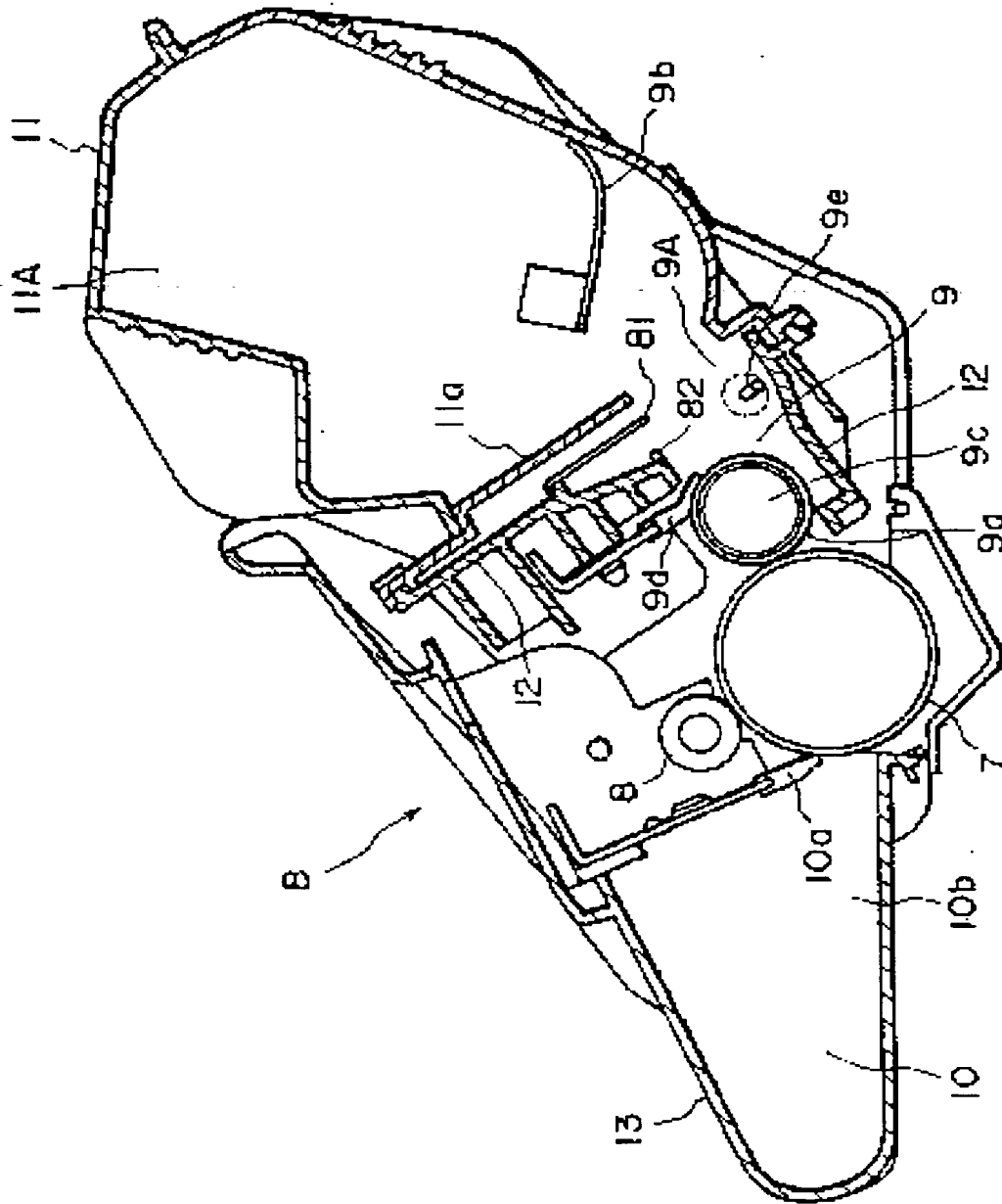


FIG. 9

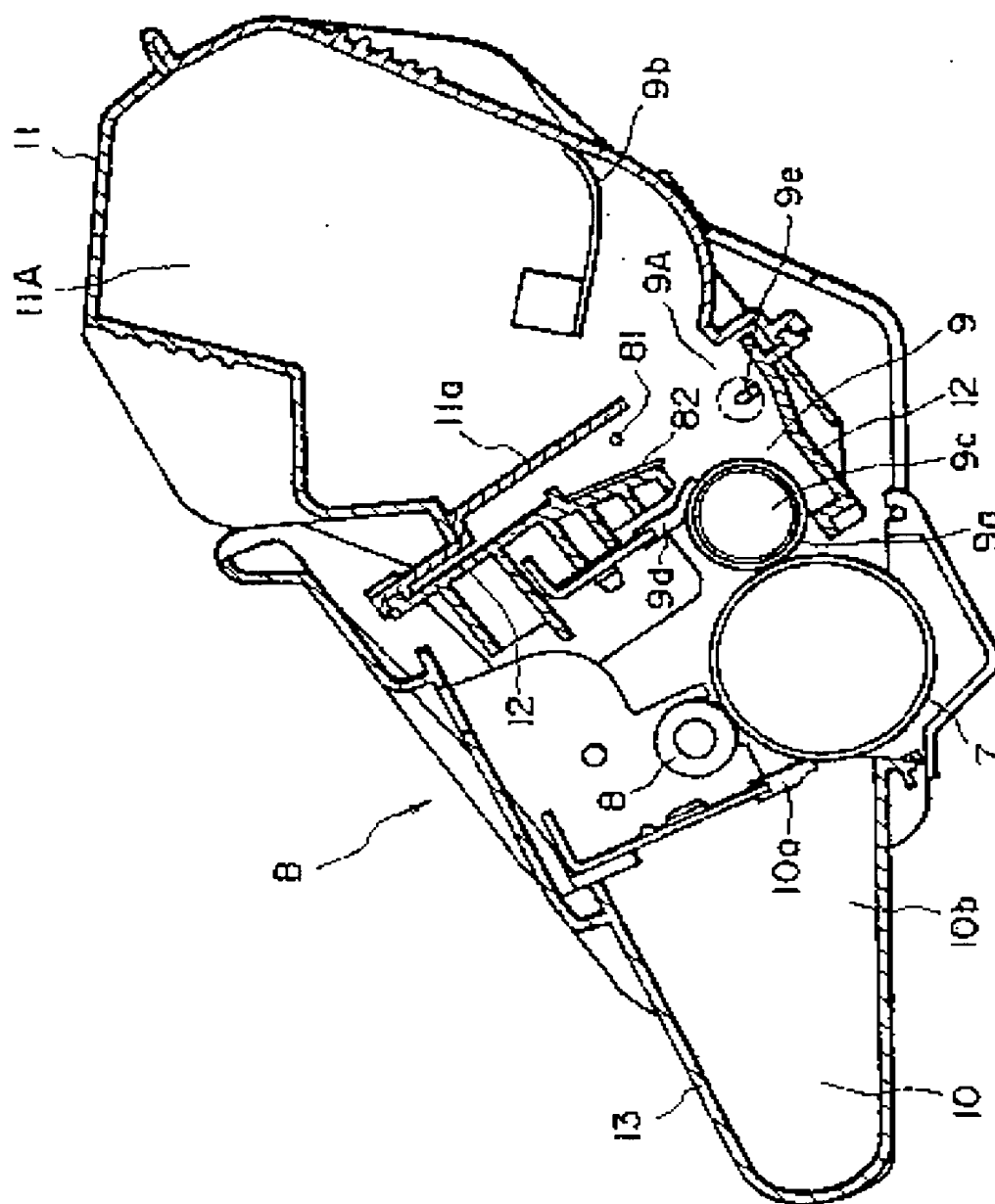
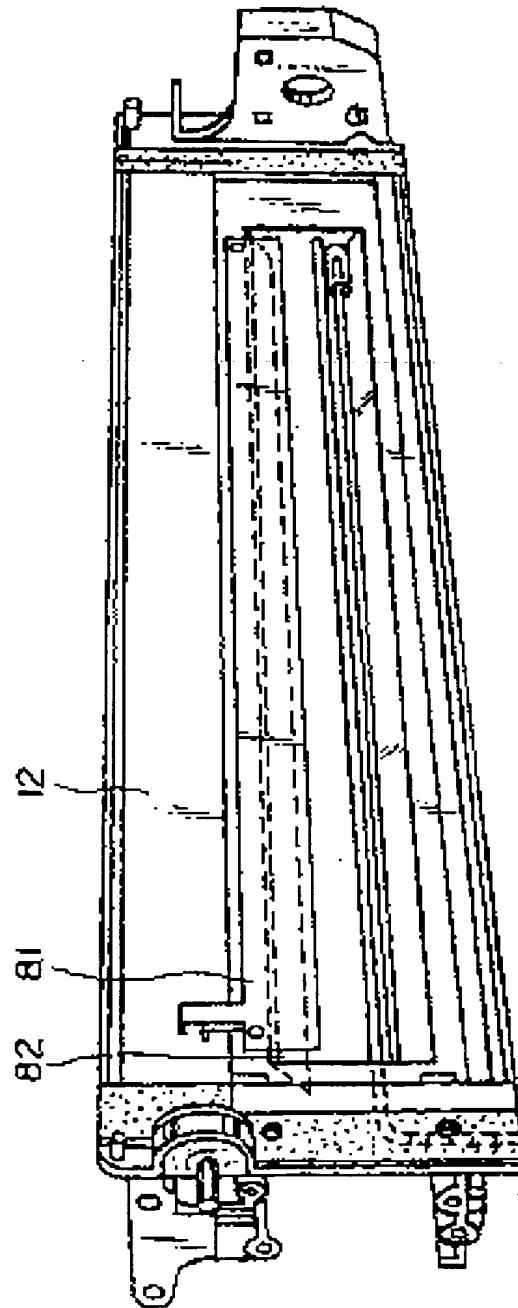
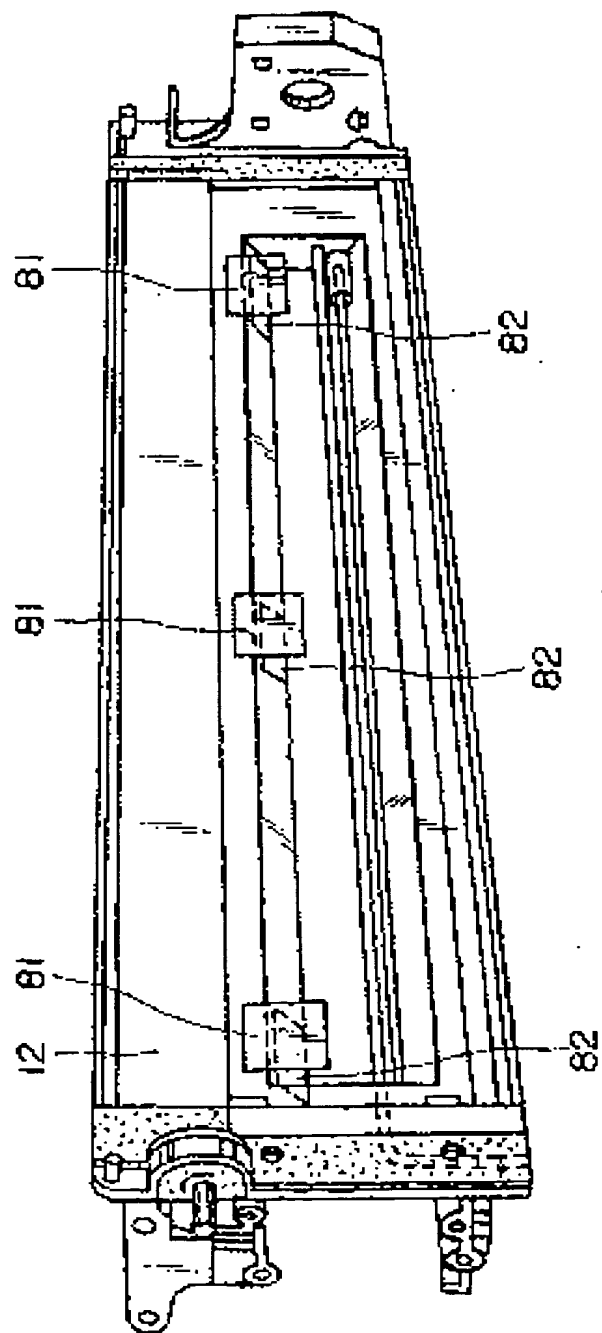


FIG. 10





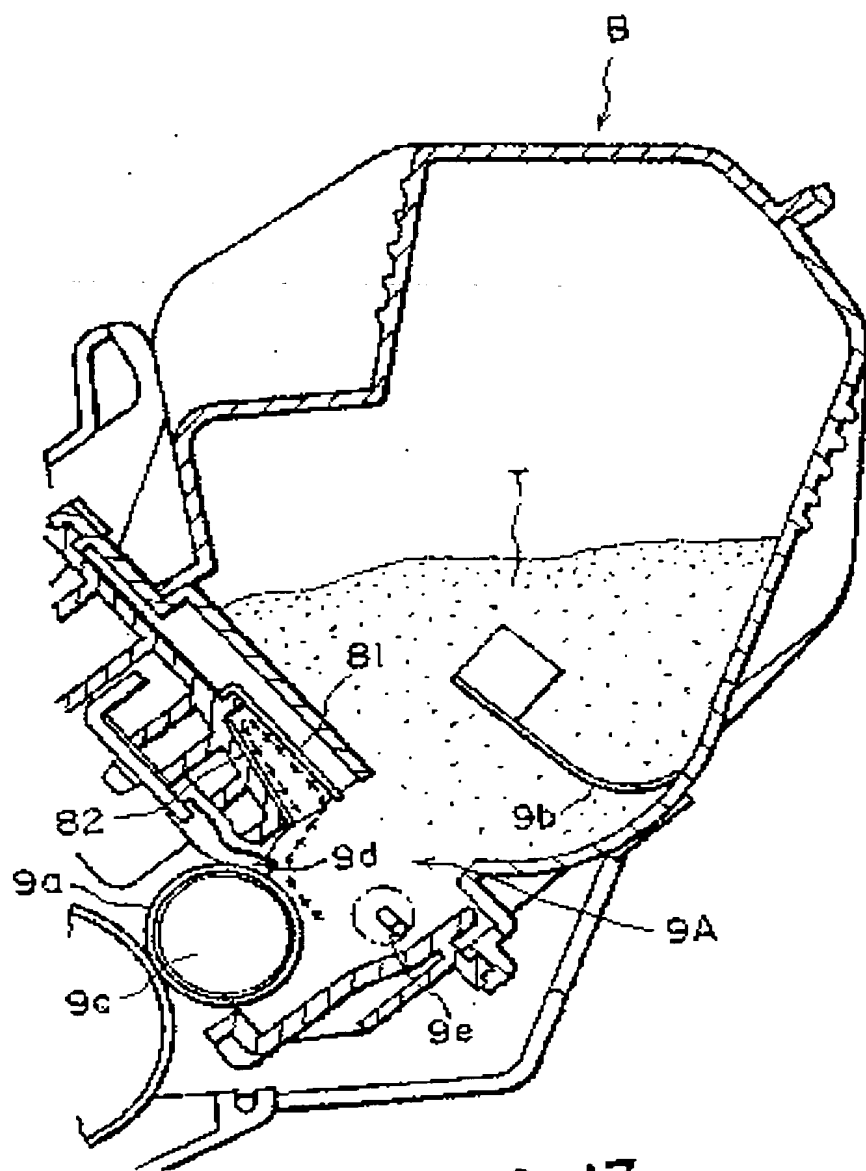


FIG. 13



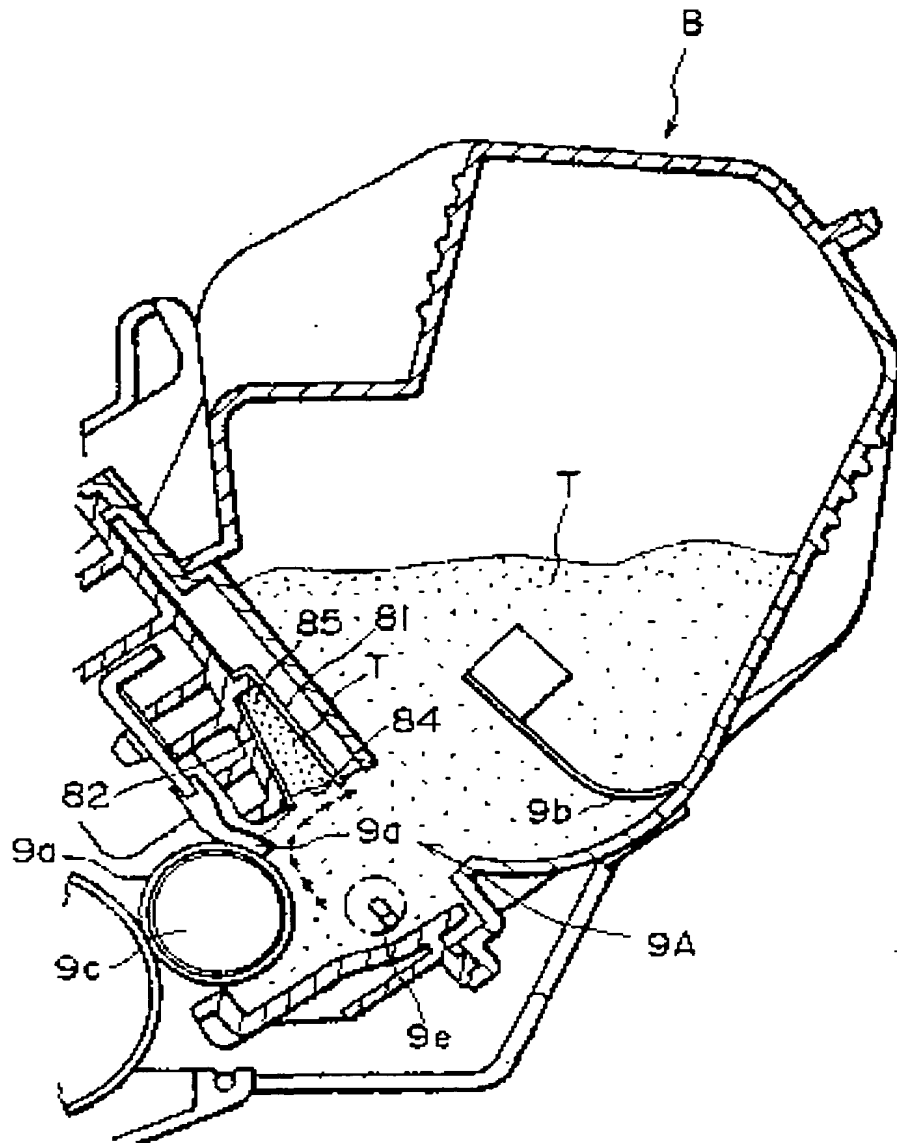


FIG. 14

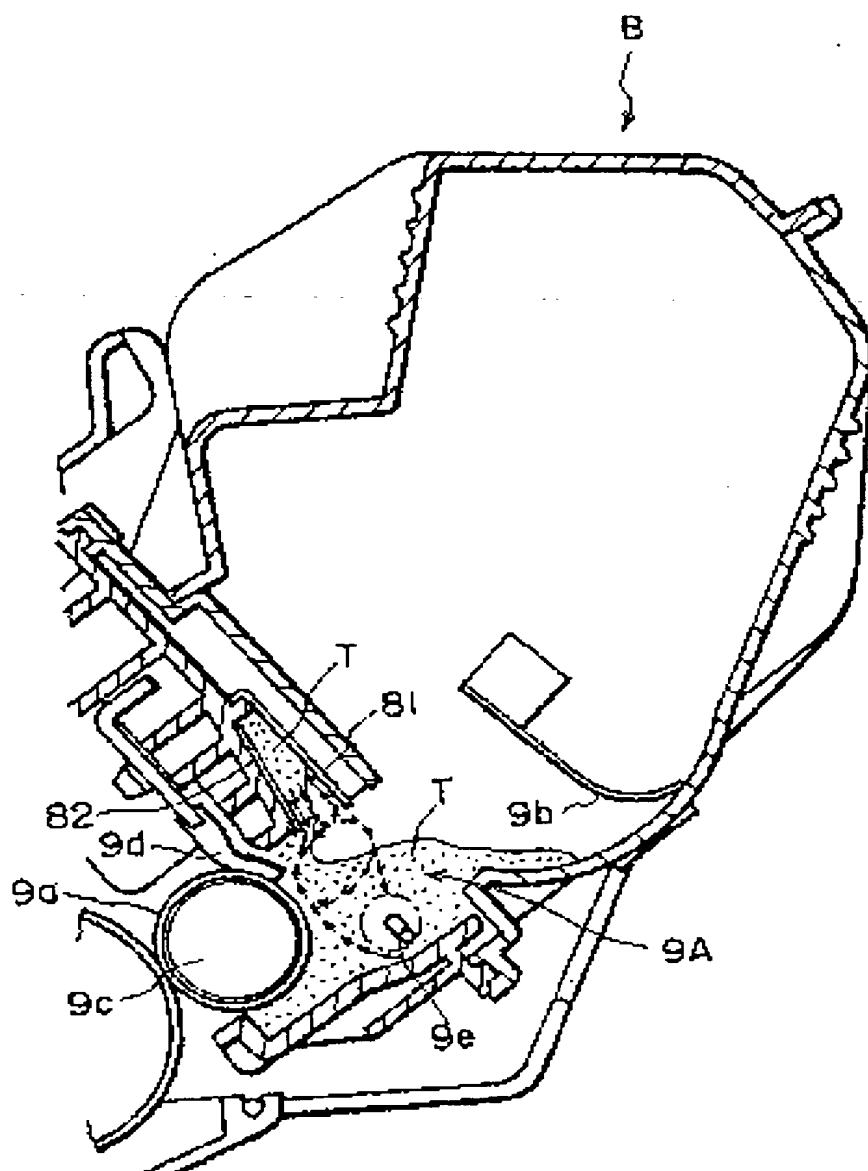


FIG. 15

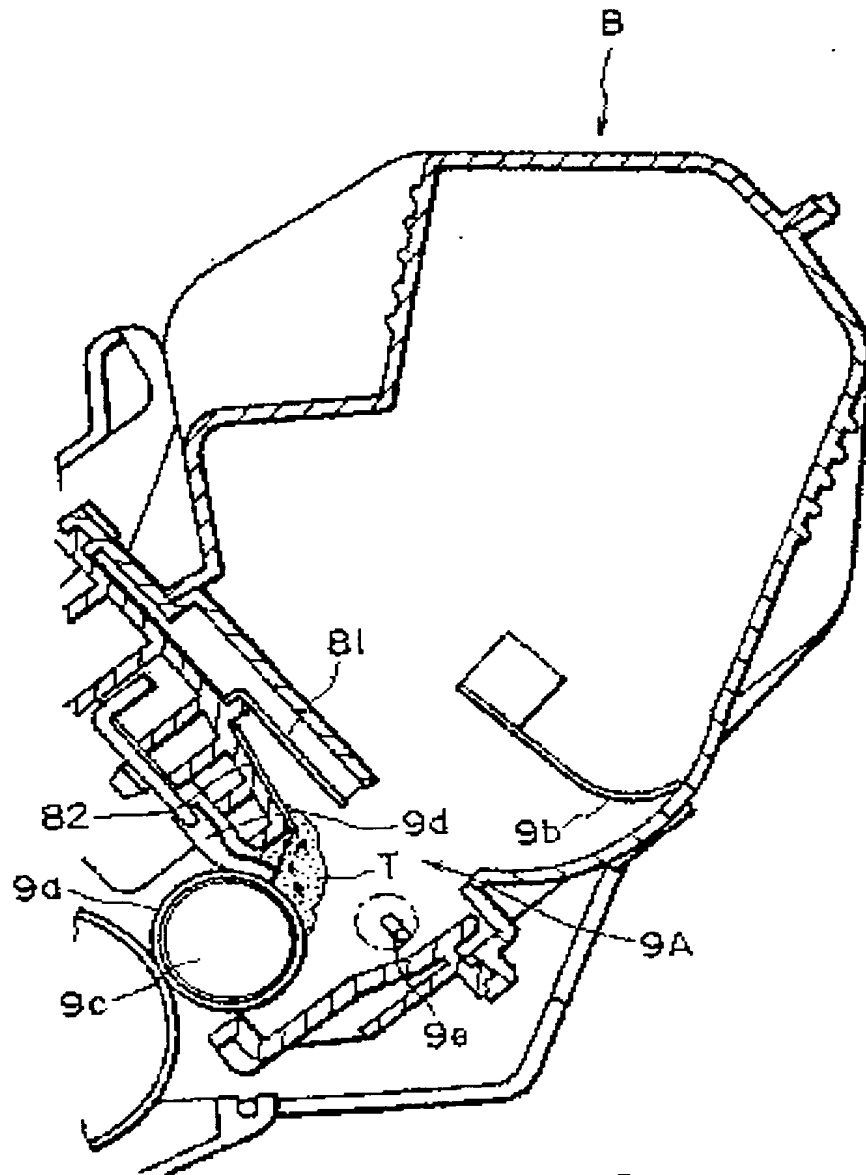


FIG. 16

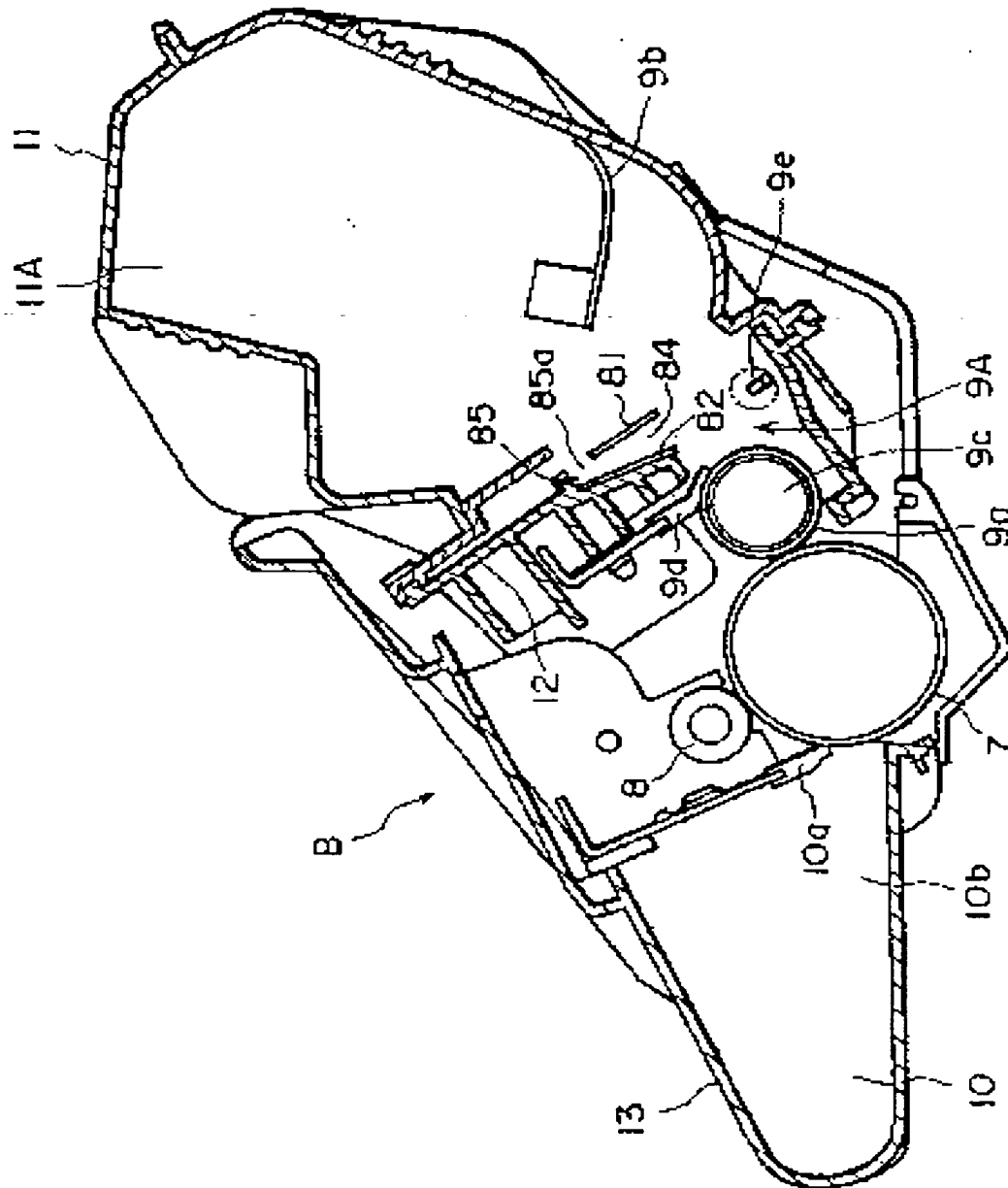


FIG. 17

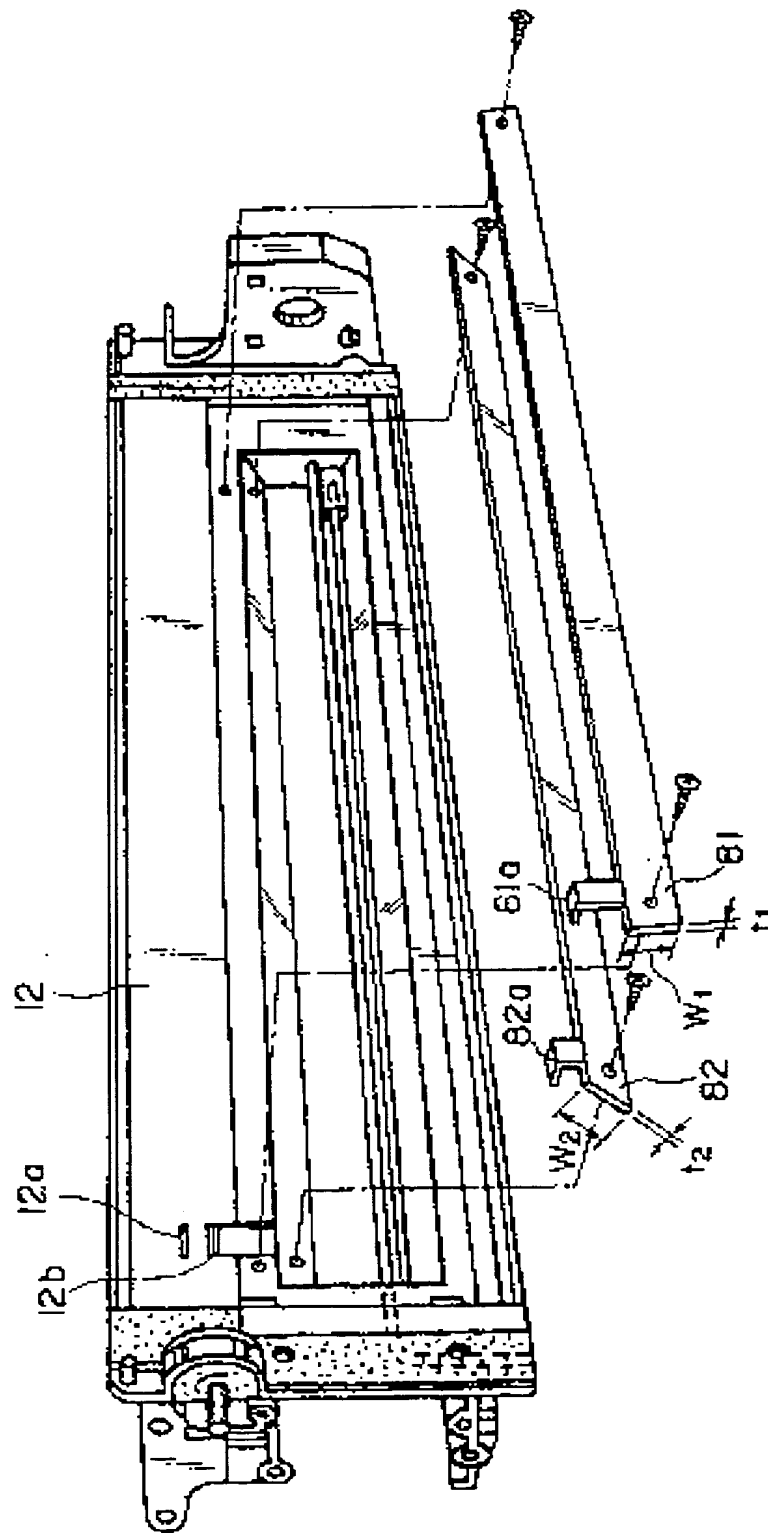


FIG. 18

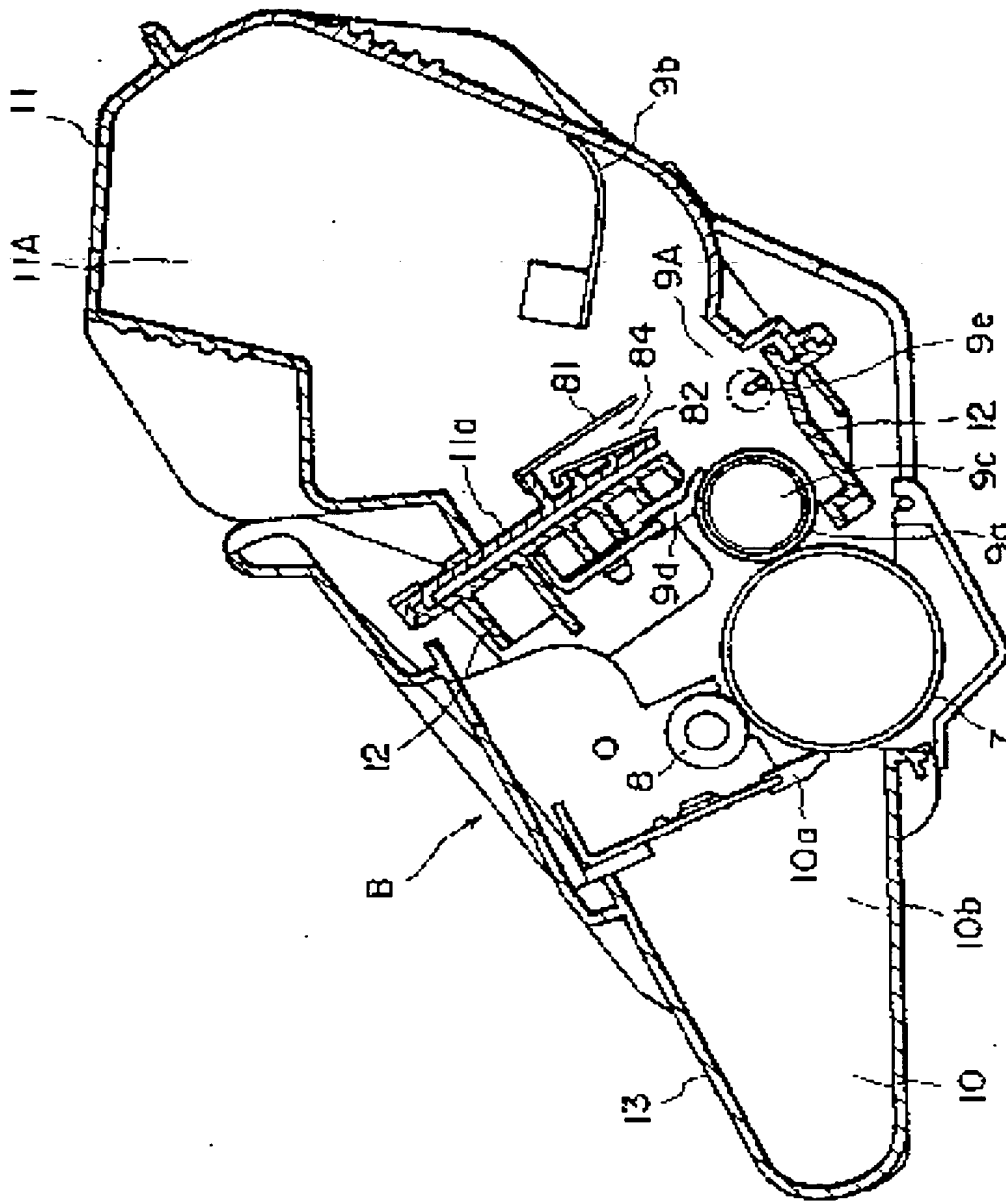


FIG. 19

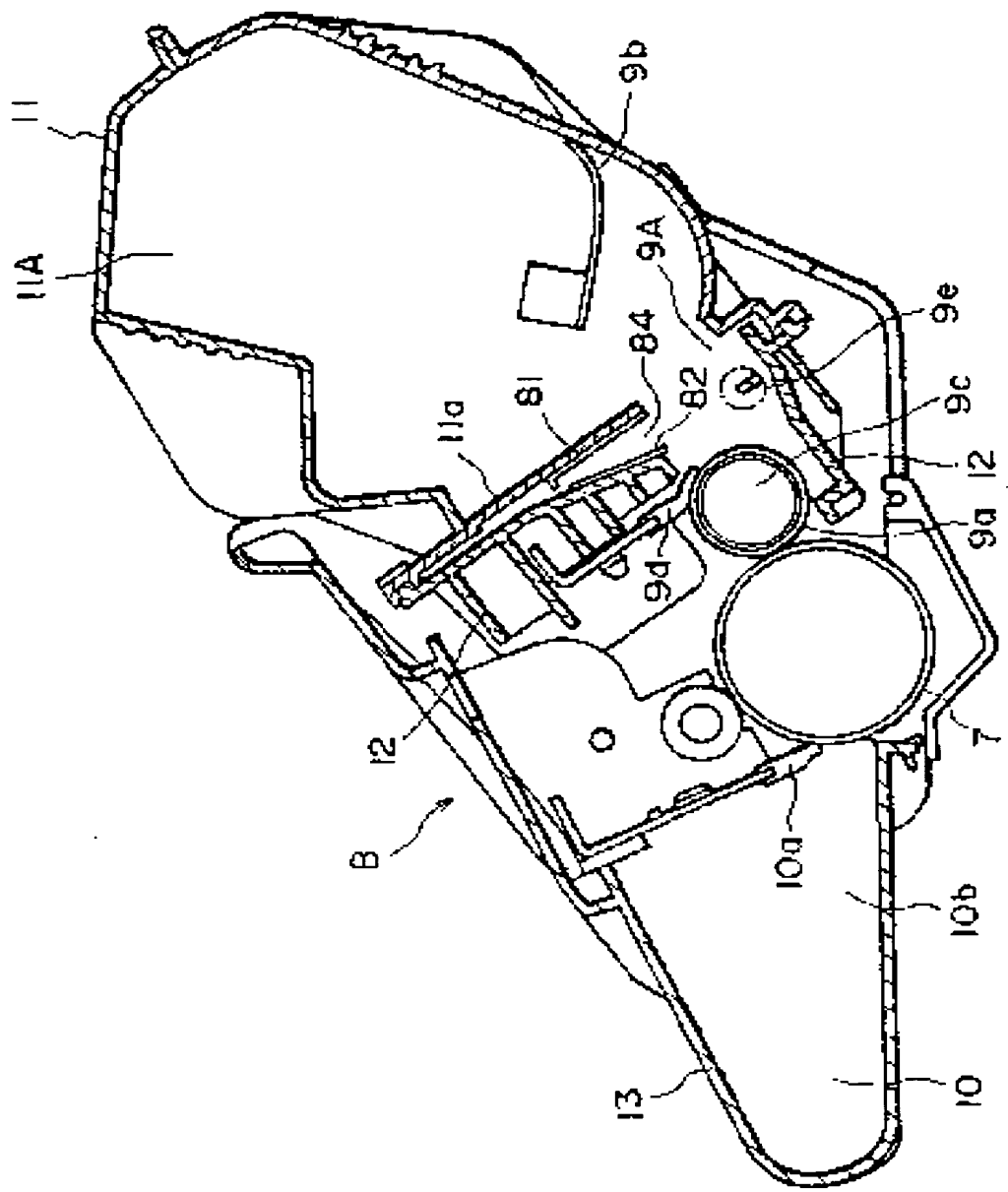


FIG. 20

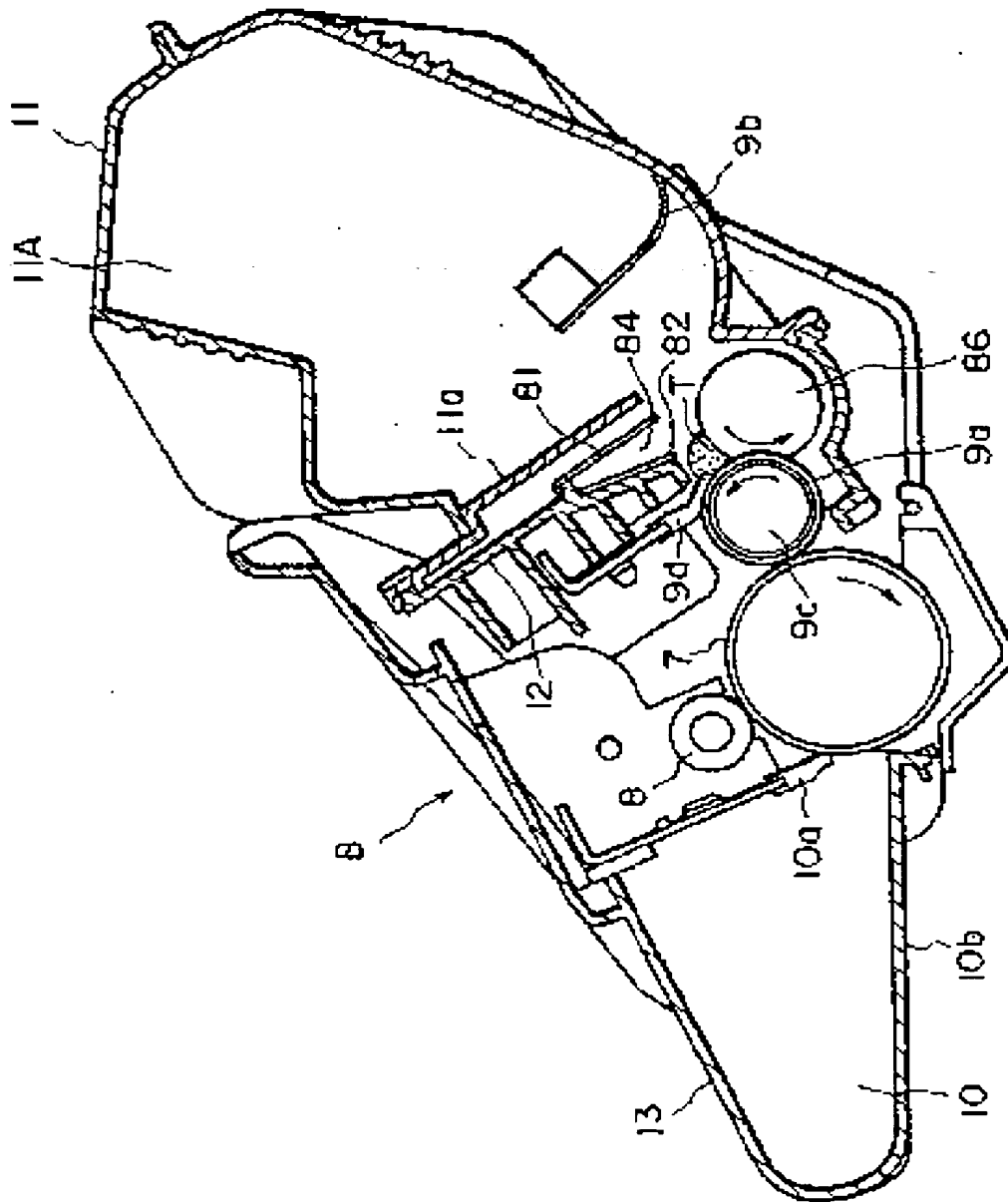


FIG. 21



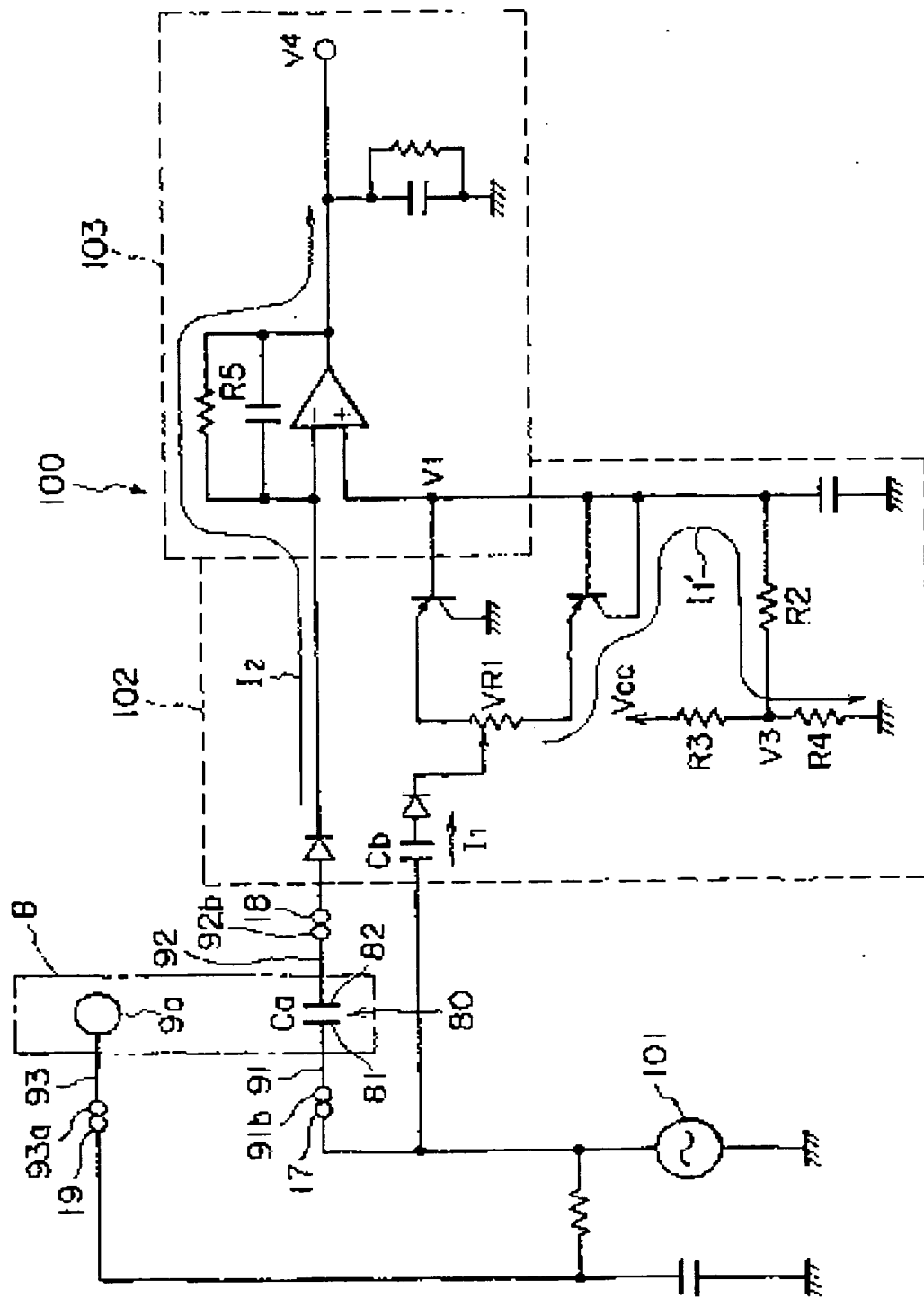


FIG. 22

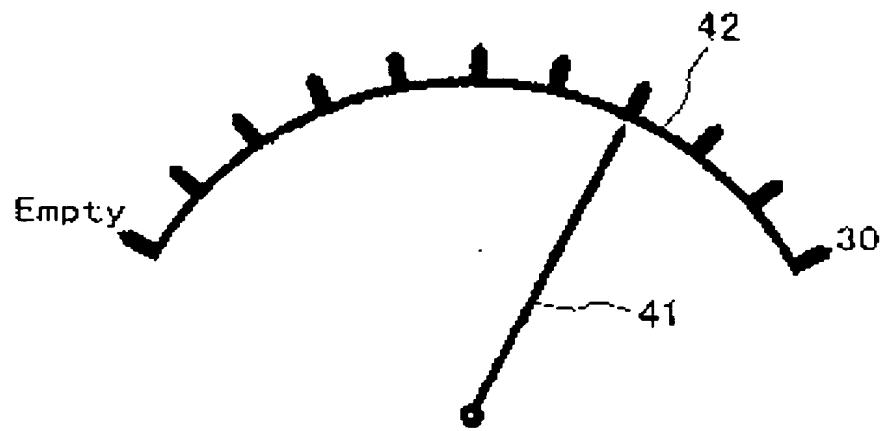


FIG. 23

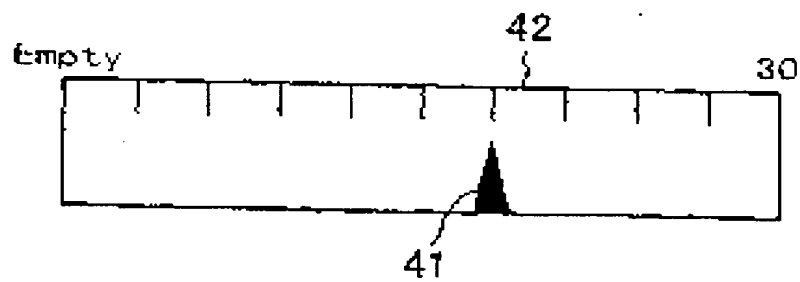


FIG. 24

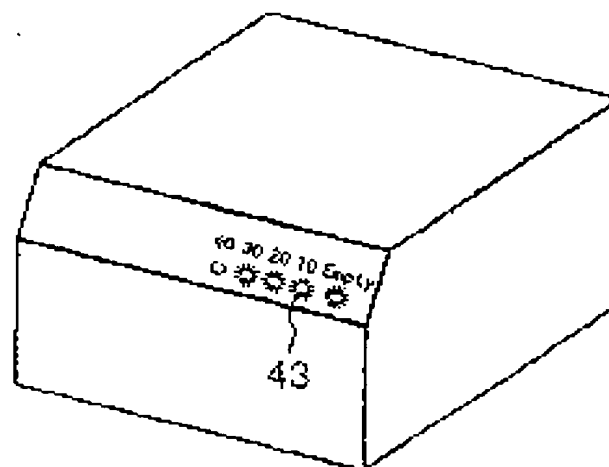


FIG. 25

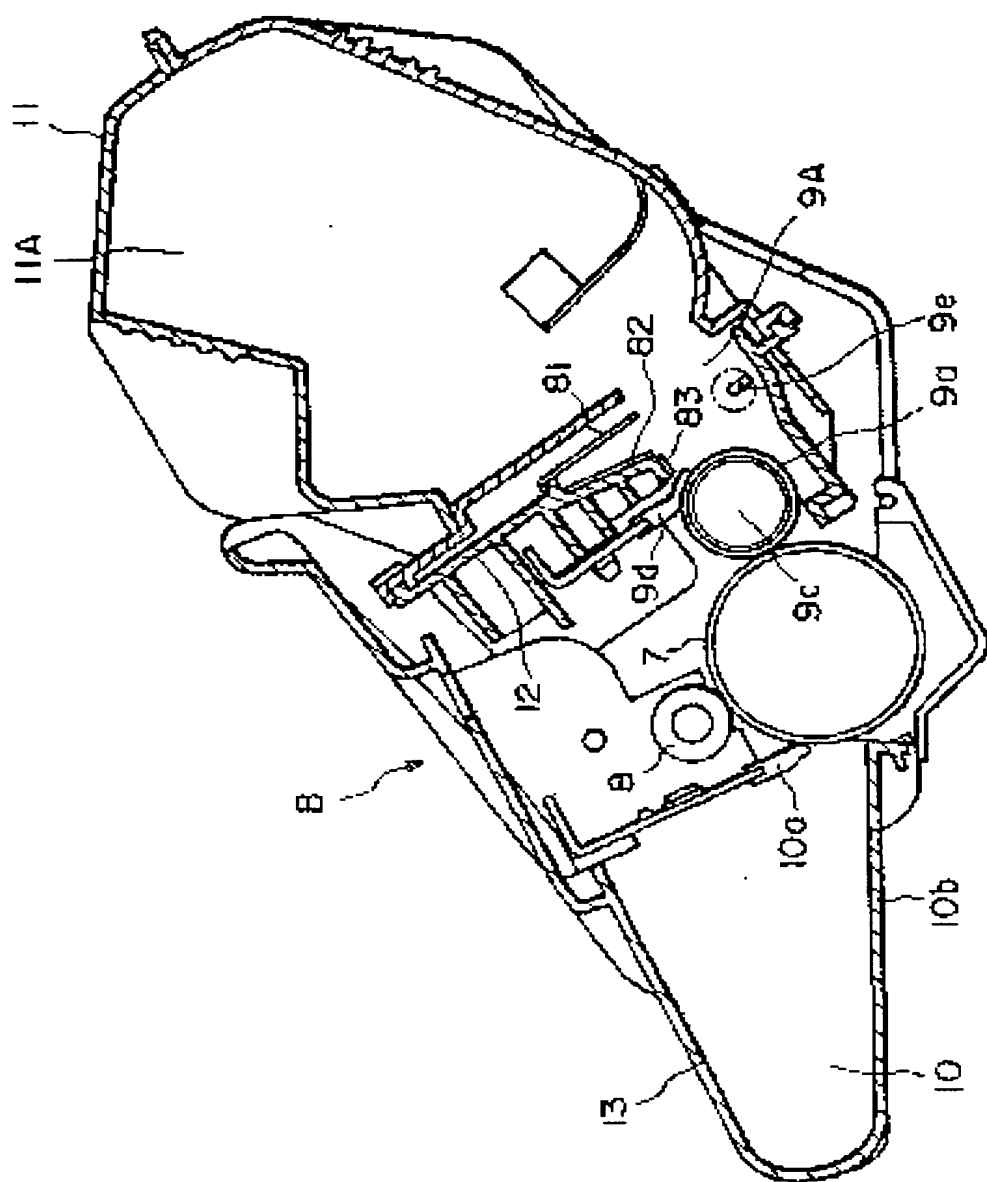


FIG. 26

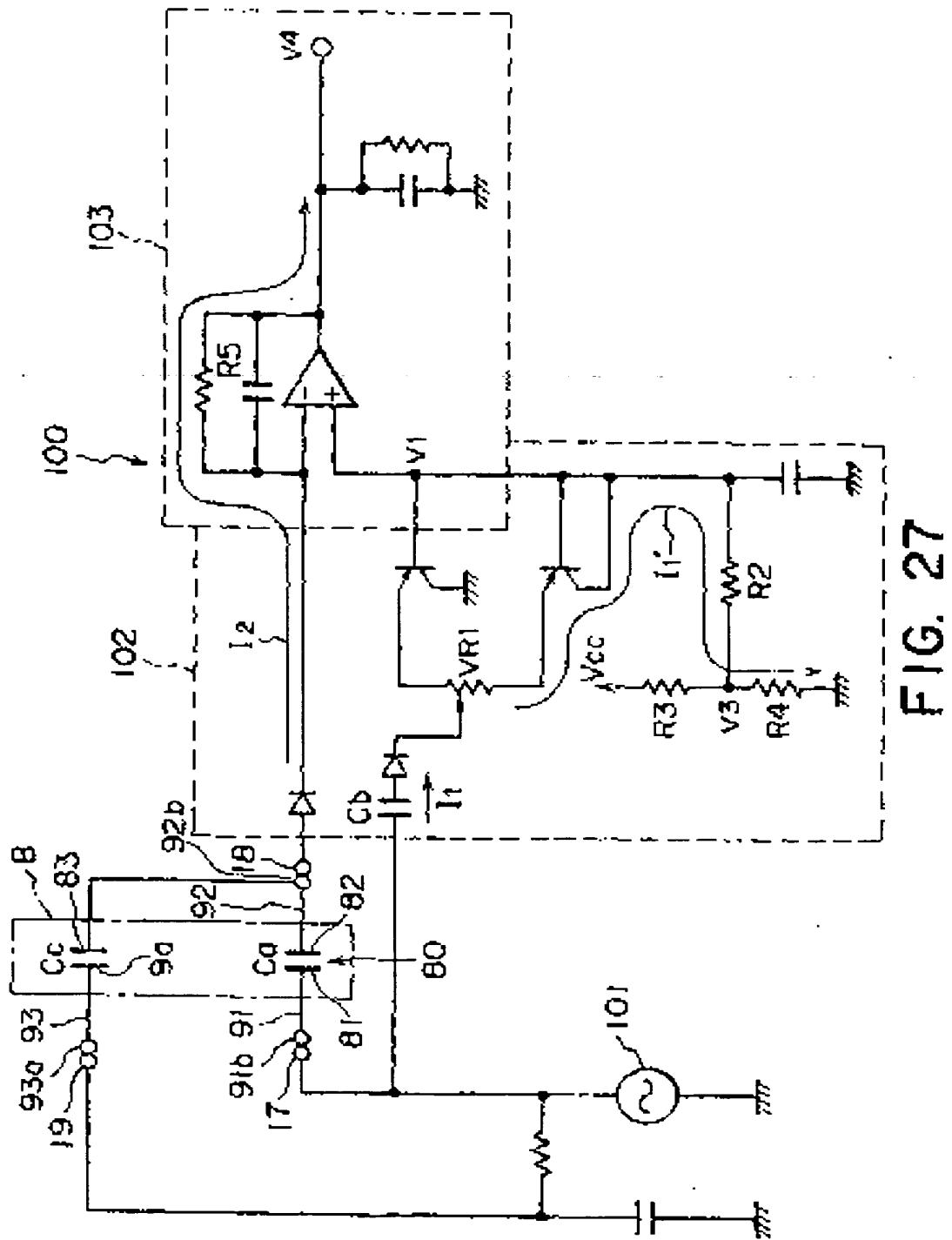


FIG. 27

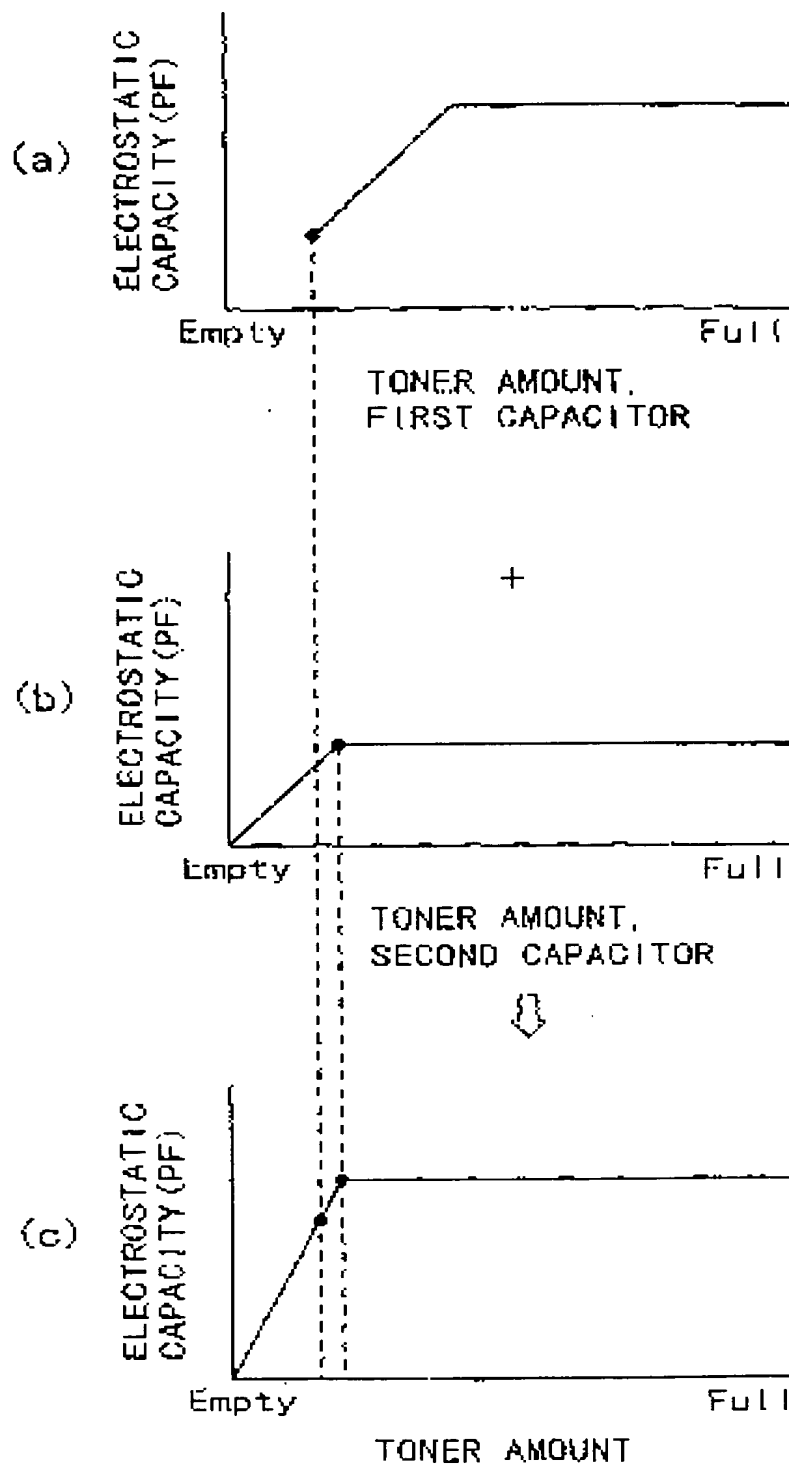


FIG. 28

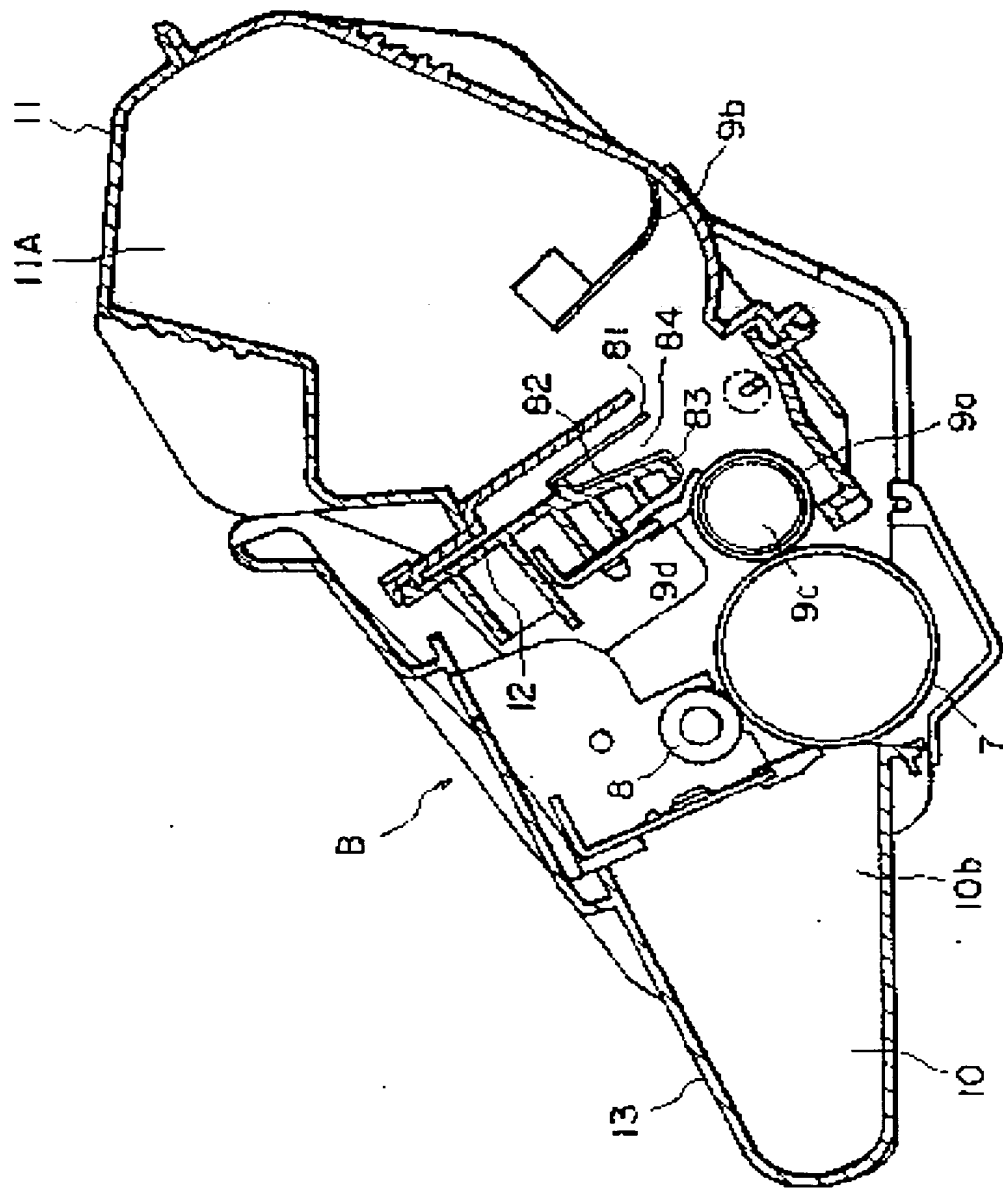


FIG. 29

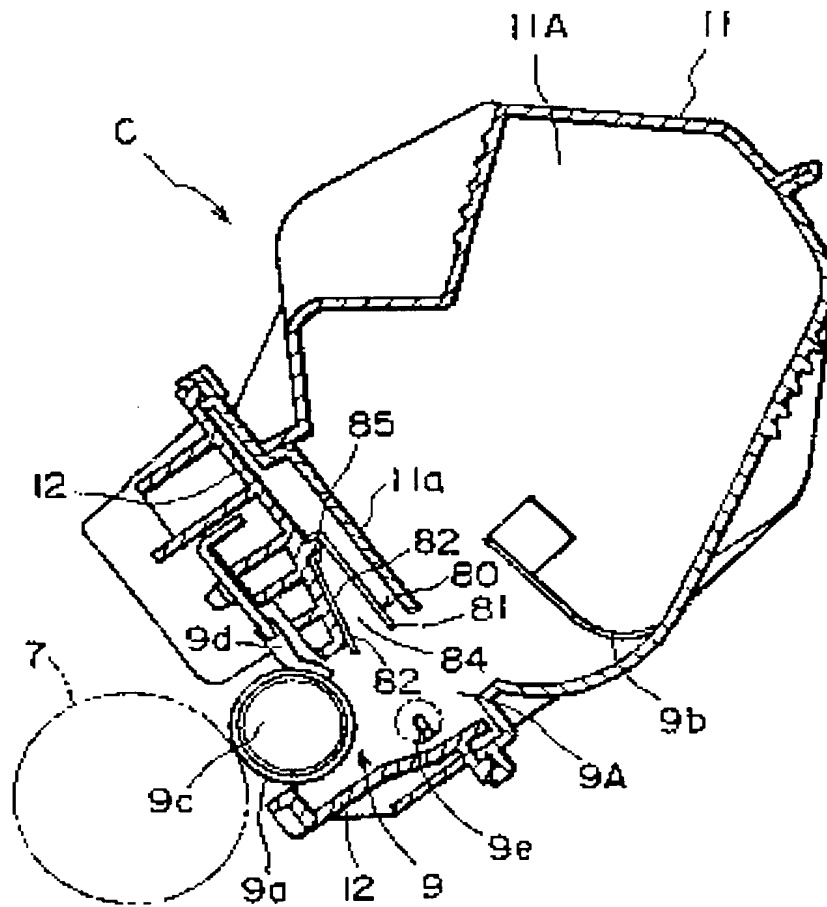
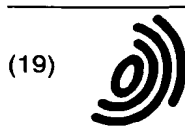


FIG. 30







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(11) **EP 1 016 939 A3**

(12) **EUROPEAN PATENT APPLICATION**

(88) Date of publication A3:  
**30.05.2001 Bulletin 2001/22**

(51) Int Cl.7: **G03G 15/08**

(43) Date of publication A2:  
**05.07.2000 Bulletin 2000/27**

(21) Application number: **99310455.3**

(22) Date of filing: **22.12.1999**

(84) Designated Contracting States:  
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU  
MC NL PT SE**  
Designated Extension States:  
**AL LT LV MK RO SI**

- Sakurai, Kazushige  
Ohta-ku, Tokyo (JP)
- Oguma, Toru  
Ohta-ku, Tokyo (JP)
- Matsumoto, Hideki  
Ohta-ku, Tokyo (JP)

(30) Priority: **28.12.1998 JP 37383498**

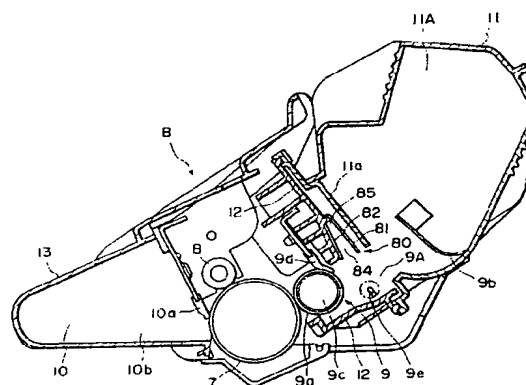
(71) Applicant: **CANON KABUSHIKI KAISHA**  
**Tokyo (JP)**

(74) Representative:  
**Beresford, Keith Denis Lewis et al**  
**BERESFORD & Co.**  
**High Holborn**  
**2-5 Warwick Court**  
**London WC1R 5DJ (GB)**

(72) Inventors:  
• Karakama, Toshiyuki  
Ohta-ku, Tokyo (JP)

(54) **Image developing apparatus, process cartridge, electrophotographic image forming apparatus, and development unit frame**

(57) A developing device for developing an electrostatic latent image formed on an electrophotographic photosensitive member (7), said developing device being mountable to a main assembly of an electrophotographic image forming apparatus, said developing device includes a developer carrying member (90) for feeding a developer to said electrophotographic photosensitive member (7) to develop the electrostatic latent image formed on the electrophotographic photosensitive member (7); a first electroconductive portion (81); a second electroconductive portion (82) for cooperating with said first electroconductive portion to provide an electrostatic capacity; a first electrical contact for receiving a voltage to be applied to said first electroconductive portion from the main assembly of the electrophotographic image forming apparatus; a second electrical contact for transmitting, to the main assembly of the electrophotographic image forming apparatus, an electric signal corresponding to an electrostatic capacity between said first electroconductive portion and said second electroconductive portion when a voltage is applied to said first electroconductive portion to detect a remaining amount of the developer by the main assembly of the electrophotographic image forming apparatus.



**FIG. 3**

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# EUROPEAN SEARCH REPORT

Application Number  
EP 99 31 0455

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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Y		2,3,5, 13,14, 21,22, 24,26, 28,29, 32,33, 41-44	
A	* the whole document * ---	4,6,8, 25,27	
X	US 5 003 917 A (TOYOSHI NAOKI ET AL) 2 April 1991 (1991-04-02) * the whole document * ---	1,20,41, 43,47	
X	PATENT ABSTRACTS OF JAPAN vol. 1997, no. 12, 25 December 1997 (1997-12-25) & JP 09 211960 A (CANON INC), 15 August 1997 (1997-08-15)	1,20,41, 43,47	
Y		48,49	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
A	* abstract * ---	2,11,12, 21,30, 31,39,40	G03G
Y	PATENT ABSTRACTS OF JAPAN vol. 018, no. 484 (P-1798), 8 September 1994 (1994-09-08) & JP 06 161242 A (CANON INC), 7 June 1994 (1994-06-07)  * abstract * ---	2,3,5, 13,14, 21,22, 24,26, 28,29, 32,33, 41-44, 48,49	
		-/--	
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>29 March 2001</b>	Examiner <b>Lipp, G</b>
<p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone Y : particularly relevant; if combined with another document of the same category A : technological background O : non written disclosure P : intermediate document</p> <p>1 : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons &amp; : member of the same patent family, corresponding document</p>			

EPF FORM 1503 (03.02.92) (P.04/01.1)



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# EUROPEAN SEARCH REPORT

Application Number  
EP 99 31 0455

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
The present search report has been drawn up for all claims			
Place of search <b>THE HAGUE</b>		Date of completion of the search <b>29 March 2001</b>	Examiner <b>Lipp, G</b>
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document I : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03 62 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 99 31 0455

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The members are as contained in the European Patent Office EDP file on  
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29-03-2001

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82